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THE TELEPHONE COMPANIES.

SYNDICATES are the order of the day. Copper syndicates, coal syndicates, salt syndicates, and syndicates for everything of which it is thought possible to secure a monopoly! Latest and last, we have to listen to what has been termed by one of our contemporaries "A Huge Telephone Syndicate." By a huge telephone syndicate we are to understand more a combination of telephone interests for the purpose of advancing telephonic communication, however, than a combination for the purpose of raising prices; and, as such, we heartily wish it a more successful journey than the first named of the bunch of syndicates with which this article starts.

That such a combination was to be looked for was natural. As pointed out by us now some time since, there could be no mistaking the intentions of the telephone interest. It meant competition, so far as its means would admit, with the Government telegraph service—competition, nothing more or less! And for this competition to prove really successful, it must mean communication over fields much more extended than at that time existed. The necessary extension has for some time been going on; trunk lines have been building, and shortly we shall be able to speak between point and point, city and city, to the utmost limits of the power of the telephone as a *viva voce* means of telegraph. That it will prove a competitor to the Postal Telegraph Department, to whom was entrusted the monopoly of serving the country with a rapid and reliable telegraph service, we shall not attempt to doubt. Whether it will prove a lucrative investment for the telephone companies is another question.

Let us consider this point for a moment. *Viva voce* telegraphy means possession of the wire between the two who have engaged, or rather secured it for a given time. Suppose we assume it to be three minutes; and in order to make the result as favourable as possible to the companies, let us say nothing for official communications, or for failures of any kind, and fix twenty as the number of communications made per hour. Say these three minutes are to be obtained at the rate of one shilling. This means twenty shillings per hour. Let us assume a service of eight hours a day, for we must remember this form of communication does not mean anything less than the actual presence of the speakers. Proxies there may be for direct questions and answers, but for real conversational business it means the business men themselves and not their representatives. Well, eight pounds a day for 300 days, gives us a result of £2,400 a year. If telephone companies can secure this for any wire, whether between London and Brighton, London and Manchester, York, Newcastle, or elsewhere, certainly the telephone companies will not grumble.

But say they get but one-fourth of this: still they will not quite go to the bottom. If they get one-sixth they will hold together; and it will be strange if they do not manage to effect this. In saying thus much we do not forget the many attendant expenses to be contended with. Offices, clerks, wayleaves! all these are present to our minds.

The main question is, will the public—business and private public—avail themselves of the telephone in preference to the telegraph? We think there are many who will. Communications of this character are now carried out to a very great extent between towns in the manufacturing districts; between the chief house and its several branches by many firms. It will be a convenience to many a man of business to speak with his chiefs when away from home; and in various ways it will, although more costly, seemingly, than the telegram, find many users.

It will not, however, prove a bed of roses to the executive of the companies for a time. One of the great difficulties to be overcome will be that attending the order in which the wires may be used. During a portion of the day there will be a great demand for them. At other times they may be comparatively idle.

So far, we understand, the combination embraces the following companies, viz.:—The National, the South of England, the United, and that serving the North of Ireland. The company serving the West of England and South Wales would appear to have held aloof as yet. The combination, however, as it stands, is a strong one, embracing the country from Inverness to Brighton with the whole of England, except South Wales, and that portion west of Worcester.

Such a combination cannot but affect the interests of the State Telegraph Department. From a pecuniary point of view the executive of that department may regard it with perfect equanimity, for whatever these extensions may mean, whatever may be the business they produce, the Telegraph Department takes its toll. It may be argued that so long as the telephone companies perform faithfully their work, the operation is as well in their hands as in that of those to whom the country delegated the duty. But this is not so. The Post Office was entrusted with a duty. A part of that duty is now being performed by others—under license, it is true. Those others seek a revenue. Should this revenue go to the reduction of the rate of telegraphy or telephony, or to the shareholder? Whatever that revenue may be is the amount which, were the undertaking in the hands of those to whom it was primarily allocated, would be available for reducing the cost of telegraphic correspondence. The Postmaster-General has recently, in his remarks in the House, taken care to emphasise his former observations on this point, but we none the less continue to disbelieve in the possibility of the two services being conducted for any length of period under two heads, one responsible to the country, the other—a commercial undertaking, responsible to its shareholders. The time will come when the Government will be called upon to fulfil the duty entrusted to it by the several Telegraph Acts passed for that purpose; and the course now taken by the telephone companies will, we doubt not, tend largely to make this all the more clear. To prolong the day is to increase the outlay which must in the end be borne.

THE CHEMICAL SOCIETY.

AT the Annual General Meeting of this Society which was recently held, a most interesting address was delivered by the President, Mr. W. Crookes, F.R.S., on "Recent Researches on the Rare Earths as Interpreted by the Spectroscope." The president claimed for the spectroscope, and, we think, with just reason, that it was the most important scientific invention of the latter half of this century. The insight which this instrument has given into the constituents of matter is perfectly marvellous and under the competent hands of various workers many of the secrets of nature are being brought to light. Many of the so-called elements have been proved to be compounds, but the extent to which this is likely to be the case in the future seems to be rapidly widening. It has been maintained by Dr. Wundt that the possible number of the elements cannot exceed 79, but Mr. Crookes sees no definite and sufficient reason for limitation to this number, in fact, he is inclined to think that it is possible that when analysis has been driven to its completion, each element will be represented by one spectral band. The so-called element didymium, has almost conclusively been proved to be a compound, and the researches of Mr. Crookes and, later, those of Messrs. Krüss and Nilson, seem to indicate that the compound is composed of several elements; the latter gentlemen, indeed, think it probable that the number is at least nine, and that many of the other bodies may similarly be split up. It is pointed out, however, that the assumption of compound molecules will perhaps account for the facts and thus legitimate itself as a good working hypothesis, whilst it does not seem so bold an alternative as the assumption of eight or nine new elements. The many conditions under which the spectra are obtained, *i.e.*, in the case of incandescence, phosphorescence, and fluorescence, are most interesting. In the conclusion, Mr. Crookes points out that atomic weight determinations are valuable in telling when the fractionating operation in use has effected all the separation it can; at this point it becomes constant, the true inference being, not that a new earth has been obtained, but simply that the fractionating operation requires changing for another, which will cleave the group of meta-elements in a different direction.

THE Paris Telephone Company, which owns the Edison carbon transmitter patent in France opened, in 1883, suit against several infringers. The Tribunal de la Seine decided that the carbon transmitters made by different parties in France were no infringment on the Edison patent. The action of the Paris Telephone Company was consequently dismissed, and the Edison patent for the (carbon) transmitter on the Continent appeared thus to be valueless. We find the judgment in *La Loi* (The Law), a judicial paper of Paris, dated February 8th, 1889. This decision will no doubt have a great influence on other tribunals on the Continent. In Belgium, the Edison-Gower-Bell Company, together with the Consolidated Telephone Construction and Maintenance Company, both of London, commenced a similar suit in 1886 against the different Bell telephone companies as supposed infringers of the Edison patent. According to the French decision, they would be no infringers. The Edison parties, notwithstanding a long opposition, were finally condemned by the different courts in Belgium to deposit a rather small caution amount for the suit, but reserve was made by the tribunals that the amount can always be increased pending the suit. This is the first decision in the Belgian action after a fight of nearly three years. When shall we have the next?

UNDER the heading "A Practical Man on Electrical Units," in the last issue of our contemporary *Nature*, a somewhat violent onslaught is made on a gentleman in the electrical engineering world, whose identity is sufficiently revealed, for some remarks which he made at a technical institute with reference to the application of electricity to industrial operations. The onslaught in question is a fine example of scientific intolerance, the writer having entirely

overlooked the fact that the audience was being addressed on a practical subject by a practical man, whose object was to show untechnical people that electrical relations were capable of being dealt with without any necessity for a knowledge of the intricate principles involved. In such a case the "Practical Man" would have been simply wasting his time if he had attempted to teach his audience what electricity is, or what he or any given number of professors might think it to be. His audience would not have understood him in the least, and he would have defeated his own ends. The pettishness of the attack may be imagined when we find that it is considered worth while to draw attention to the accidental displacement of a decimal place in a numerical example which was given in a general illustration, where such a mistake could not possibly mislead. The tone of the article indicates that the writer's opinion is that the professorial circle is immaculate and absolutely beyond the range of contradiction, and that the practical man must be allowed to exist on sufferance only.

ALTHOUGH there are unfortunately several pure theorists whose self-sufficiency is, to say the least, not a little repulsive, there are many more who, though mighty in pure theory, are at the same time thoroughly practical, and who estimate the work of the practical man at its real value, and, moreover, when they do hit hard and sharp and draw attention to mistakes, do so in a manner which, though perhaps annoying, is widely different from that of the example we have referred to. Without in the least wishing to underestimate the work of the theorist, we think it is an open question whether in fact the advance of pure science does not owe at least as much to the practical man as to the theorist. Certainly the theorist would not have a comfortable University chair were it not for the fact that a certain number of the people that sit at his feet do so only in the hope that they may be able to unravel from his theories some little practical knowledge which may enable them to earn their bread in a practical manner.

WE cannot help thinking, however, that it is a great pity the "Practical Man" gave the Professor, who, we imagine, can generally be found "within a mile of Edinbro' town," such a loophole for attack; but it may yet turn out that the former was incorrectly reported, and that he had no opportunity of correcting proofs for press, although *Nature's* correspondent gratuitously assumes that such a course must necessarily have taken place. As quoted, the statements are certainly loose and not representative of the class of men so viciously attacked; therefore, if they are not due to the causes we suggest, the lecturer must not be considered as a fair specimen of his kind. The Professor is apt to forget that his position in the world is largely the result of reaction between practice and theory; and without going too strongly for the electrical professor as a class, we take the opportunity of gently reminding him that he had better keep to his own sphere and leave the "Practical Man" to carry out his work in the way which may seem good to him. The electrical industry has been quite enough disturbed by the professional clique, and the comparatively light esteem in which that clique is now held shows that a movement in another direction is taking place.

IN our last week's issue we referred to the proposal made by Major Flood Page at the general meeting of the Electrical Trades Section of the London Chamber of Commerce, that a working secretary should be appointed to look after the interests of the industry, subject to the authority of Mr. Kenric Murray. We are now glad to learn that Mr. A. P. Trotter, with the designation of "correspondent" to the section, has been selected. There is every reason to believe that Mr. Trotter will quickly grasp the duties which will be required of him, and members of committees need no longer be in doubt as to the results of their conferences or communications with the authorities who control certain of their operations. The section may be congratulated upon the appointment of a gentleman so well qualified, whether from a practical, scientific, or literary point of view, for the post; and for the information of those who wish to communicate with him at any time, we may add that his address is 2, Victoria Mansions, Westminster.

THE "Brooks" system of underground wires has frequently figured in our columns, and was not long ago the cause of a lively controversy between the genial David Brooks and several of our correspondents. It may be of service to those who wish to become more fully acquainted with this method of laying subterranean conductors, that Messrs. Johnson and Phillips have been appointed sole licensees for the manufacture in this country.

ON page 417 of our present issue we give a *resumé* of the decision in a suit brought by the Electrical Accumulator Company of New York (licensees of the Electrical Power Storage Company) against the Julien Electric Company of the same city, upon four patents, one patent of Shaw and Rogers, one of C. A. Faure and two of J. W. Swan. The first of these was withdrawn by the plaintiffs from the litigation and given up. Both Swan patents were declared to be invalid by the decision of the Court; of the two claims of the Faure patent sued upon, one has been declared to be invalid, if broad enough to be infringed, and the other has also been held to be invalid in its present form. The court has pointed out that if the Faure people disclaim everything except one particular way of applying the coating, and limit the patent to that narrow and restricted species of secondary batteries, the court can sustain such a claim. The court having held all the claims declared upon by the plaintiff to be invalid, awarded no costs to complainant. This is a triumph to the Julien Company, and to many others, no doubt, who make storage batteries differently from those of Faure, as limited by the United States Court.

THE following appeared in the *Standard* of Wednesday:—"Shortly before noon yesterday an explosion occurred at the works of the Electric Light Supply Corporation, Limited, Storage Wharf, Deptford, resulting in the immediate death of one man and serious injuries to three others. A copper pipe communicating with one of the boilers was being used for the first time, when the 1,500 horse-power force proved too great for the strength of the pipe, which, although 19 inches in diameter, was only $\frac{3}{16}$ths of an inch thick. The result was an explosion which alarmed the neighbourhood. The man killed, Joseph Selway, of 9, Henrietta Street, was thrown a distance of about 15 yards, and afterwards fell 18 feet into the basement of the building. The other men were blown many yards. They were subsequently conveyed to the Seamen's

Hospital, Greenwich, where one lies in a precarious state. The Board of Trade inspector was on the premises at the time of the accident." Now, this is really a great misfortune to befall a company just on the point of attempting to introduce electric lighting into London on a scale, and in a manner, hitherto scarcely dreamt of, and we sincerely regret its occurrence. Doubtless we shall learn in a short time, from official enquiries into the cause of the accident, whether the result was due to want of engineering knowledge in designing the machinery, or to one of those unfortunate circumstances which no human skill appears capable of providing against. Whatever may be the cause, it is a matter for grave consideration, and the trial of other portions of the machinery in the Deptford station will be watched with mingled feelings of hope and fear. The disaster is a curiously suggestive commentary upon the evidence of Sir William Thomson on Monday, at the Board of Trade enquiry into the applications for electric lighting orders and licences. In answer to a question put to him, Sir William said :—"It was possible to imagine that a station might be wrecked, but with proper care that ought not to be taken into account for practical purposes."

WE are not always at one with Mr. W. H. Preece, nor do we invariably consider his papers possessed of any great value scientifically or practically, but everybody must concede that his communication to the Institution of Electrical Engineers, which we published last week, was of a most serviceable nature, and that it appeared at a very opportune moment. His experiments show very conclusively that such arrangements as those proposed by the London Electric Supply Corporation for running main conductors under 10,000 volts difference of potential cannot be tolerated when alternating currents are employed, although there appears to be no reason to restrict the use of conductors of a similar kind when the currents are continuous. It will be remembered that the outer tube of the Ferranti conductor, which is bare, was to be earthed at every point of support, and that in this laid its safety; some other method of fixing will now be rendered necessary.

OUR readers are already acquainted with the construction of Mr. Ferranti's concentric tube main conductor, which is to be used between Deptford and the distributing stations. They also know that the electromotive force to be employed is no less than 10,000 volts, and that perfect immunity from danger is claimed for the system. The insulation also is of the most wonderful character—the 10 inch spark of a Wimshurst machine, with its hundreds of thousands of volts, having no effect upon it. It is indeed surprising how dust is thrown in the eyes of the inexperienced by drawing conclusions from laboratory tests such as these. It will be remembered that a short piece of Henley's patent ozokerited India-rubber covered core was subjected by Profs. Ayrton and Perry to a strain of 14,000 volts without any appreciable injury, but neither Henley's Telegraph Company nor the Professors would think for a moment of using a tenth part of this electromotive force on a seven mile length of cable, especially with alternating currents, unless for the express purpose of breaking it down. However, time will show whether Mr. Ferranti's cable will prove successful or otherwise.

NOTE ON THE EFFICIENCY OF SMALL ELECTRO-MOTORS.

By H. E. H. CLIFFORD, S.B.

SOME results of efficiency tests on small motors, which I published in the *Technology Quarterly* for September, 1887, have been very unfavourably criticised by Profs. Ayrton and Perry in the *Philosophical Magazine* for July, 1888. Through an apparent misunderstanding of my tables, they assert that the motors were not run at the potential differences and currents for which they were wound, and hence that the results "are not only valueless, but are most misleading."

Undoubtedly, their mistake arises from accepting the potential differences and currents given in Table I. as the maximum values, or nearly so, at which the motors were run. A glance at Table II. will show, however, that in the typical series especially selected for illustration of the effect of varying speed, the number of watts supplied to the motor was largely in excess of the number for maximum efficiency, while a comparison of Tables I. and III. shows that so far as the out-put of the motors is concerned, the experiments were by no means confined to a limited range.

At the time the tests were carried on, very little information could be obtained as to the proper conditions under which most of the motors tested (including the Ayrton and Perry motor) were to be run. Consequently a large range of potential differences and currents was used, the speed also being varied between wide limits. In the case of the model Edison dynamo, which was selected as illustrating the relation of speed and efficiency, and which was known to be wound for 100 volts and 0·8 of an ampère, the range of C, E.M.F. and speed was not so great as with the other machines tested. Profs. Ayrton and Perry base their assertion on the results of the tests upon their own motor, which, they state, was supplied with less than one-quarter of the power at which it was intended to run.

The facts of the case are that the Ayrton and Perry motor used was the one tested at the International Electrical Exhibition of the Franklin Institute at Philadelphia in 1884, where, with a speed of 1,500 revolutions a minute, an efficiency of 28·5 per cent. was obtained as against an efficiency of 38·4 per cent. with a speed of 831 revolutions a minute found by us.

In our tests it was supplied with as many as 400 watts and run at as great a speed as 1,700 revolutions per minute. It is possible that the Ayrton and Perry motor of the type tested was designed to utilise four times the power at which it was found to give its maximum efficiency, but it is certain that the especial motor tested could not by any possibility have been run under such conditions in practice, or indeed run continuously for more than a few minutes, without rapidly destroying it, since intolerable heating of the armature and most damaging sparking at the commutator would have resulted. The conditions for maximum efficiency which we found, however, were those given in Table I., and the maximum out-put is that given in Table III.

It is of course understood that in the tests the motors were not habitually run with heating of the machine, or sparking at the commutator, greater than would be compatible with practical use; but in every case the motor was tested for maximum out-put.

Bearing the facts stated in mind, it is clear that the range of the tests was in every case great enough to include the proper conditions for the individual motor tested.

The results given in my article are wholly those obtained by students, and are unquestionably subject to the defects incident to such work, but they are nevertheless trustworthy within the limits claimed, and I think also of some interest in view of the great paucity of published results relating to motors of the class under discussion.

THE STRENGTH OF THE MICROPHONE CURRENT AS INFLUENCED BY VARIATIONS IN NORMAL PRESSURE AND MASS OF THE ELECTRODES.*

By ANNIE W. SABINE.

THE experiments described in the present paper, undertaken at the suggestion of Prof. Cross, constitute a study of the variation of the current in the secondary circuit of a microphone transmitter, as related to variations in the normal pressure and in the mass of the electrodes of the microphone. They form a continuation of work of a similar character which has been prosecuted in the Rogers Laboratory during the past few years, and a portion of which has already been presented to the Academy.

The instruments used were similar to those previously employed by Messrs. Patterson and Tucker, and described in the latter of the two articles just referred to. The electro dynamometer was calibrated by means of a Hartmann galvanometer, using reversals in the ordinary manner so as by four readings to eliminate the effect of the earth's magnetism on the suspended coil.

The microphone contact was set into vibration by the sound of a stopped organ pipe (C_4 of 512 vibrations) kept as constant as possible by means of an air blast furnished with a regulating air chamber. Weights were gradually added to the upper (anvil) electrode, so that the mass of this and its pressure on the lower electrode were thereby increased by measured amounts. The weights added were usually in the form of thin copper washers weighing $\frac{5}{10}$ths of a gram each, though fractions of this weight were used in some cases. One chromic acid cell was used as a battery.

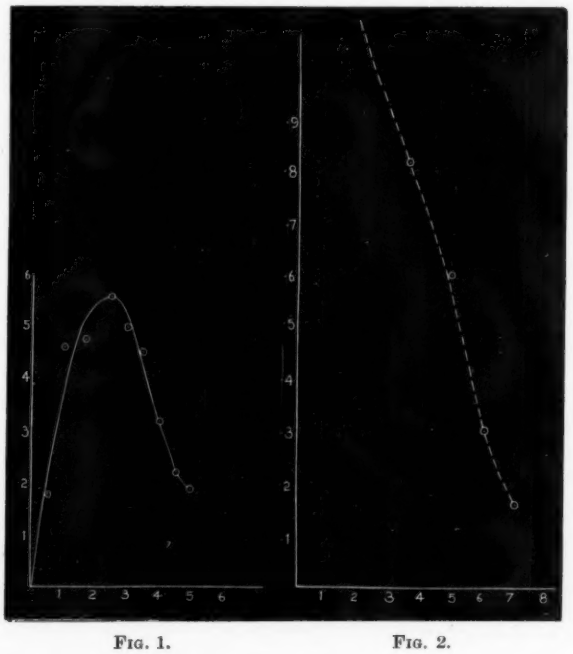


FIG. 1.

FIG. 2.

The character of the results obtained will be seen by an inspection of fig. 1, which gives the curve showing the relation between the normal pressure and the resulting current, with electrodes of the materials employed in the Blake transmitter, viz. a platinum hammer and a hard carbon anvil electrode. The abscissæ represent the normal pressures, *i.e.*, the added weights, and the ordinates the currents produced in the secondary. The data from which this curve is constructed will be found in the following table. The load is given in terms of the arbitrary unit employed; the currents are given in milliampères.

Load.	Current.	Remarks.
0	0	
·5	·18	
1·0	·46	Loud, good quality, fluttering.
1·5	·48	" " "
2·5	·56	" " "
3·0	·49	
3·5	·45	Faint, good quality.
4·0	·33	" "
4·5	·21	
5·0	·19	

The curve shows a rapid rise at first, as the mass of the anvil electrode, and with it the pressure between the electrodes, is increased, which rise soon reaches a maximum, the curve then falling off rapidly at first, more slowly afterwards.

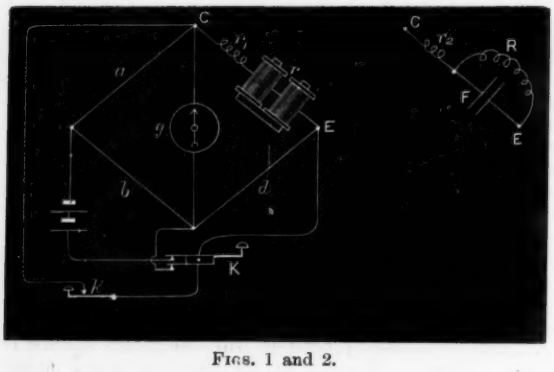
The nature of the curve is interesting, and requires explanation. In his article already referred to, Mr. G. W. Patterson, who obtained similar results to my own, considers the curve to be composed of two separate branches, the rising portion of the curve corresponding to a motion of the electrodes sufficient to break the circuit, and the falling portion to the case when the pressure is too great to allow this to occur. The curve constructed upon this hypothesis greatly resembles one of the experimental curves shown in fig. 2 of the same paper. There is less resemblance, however, to the lower curve in fig. 2, and but little to the curve shown in fig. 1 of this article, which was obtained under exceptional conditions of quietness of the piers upon which the apparatus was placed. The sound in a receiving telephone placed in the secondary circuit is so harsh for this portion of the curve, that one might well infer that actual breaks occurred; but this is very doubtful, and such breaking is certainly not essential to the production of the results which are obtained. In fact, the article referred to assumes that the varying pressure on the contact due to the action of the given sound waves will always have the same maximum value. This would be approximately true were the normal pressure between the two electrodes alone to be varied, but the effect of the addition of weights, as in the method of experiment adopted, is to increase the mass at the same time that the normal pressure is increased, and under these circumstances the effect of a sound wave of given intensity will necessarily be to give to the corresponding pressure variation a variable value, increasing with the added mass, and hence, with the form of apparatus used, as the normal pressure is greater. The effect of this will be to cause at first a gradual increase of current in the secondary, which increase is succeeded by a diminution of current when the mass is still further increased.

* Abstract of Paper read at a meeting of the American Academy of Arts and Sciences, November 14th, 1888.

Magnetisation of Iron at High Temperatures.—In a paper communicated to the Royal Society, Dr. J. Hopkinson gives the results of some determinations of the curves of magnetisation of iron at varying temperatures up to that at which the iron ceases to be magnetic. The temperatures were estimated by the resistance of a copper secondary coil. The results plotted out as curves illustrate what has been long known, that rise of temperature causes increase of induction if the magnetising force is small, but diminution of induction if the force is great. In the last curve the abscissæ are temperatures, the ordinates are the ratios of induction to magnetising force or permeabilities for a force of 4·0, and of 0·3 C.G.S. units, the data being supplied from the preceding and other curves. The latter curve brings out a most remarkable feature. For this force the permeability increases somewhat steadily to a temperature of about 640° C., its rate of increase then rapidly accelerates, till it attains a maximum of 11,000 at a temperature of 727° C.; at 737° C., the permeability is practically unity, or the magnetisability of the material has entirely disappeared.

THE MEASUREMENT OF SELF-INDUCTION COEFFICIENTS.

HAVING had occasion recently to measure the self-induction coefficients of some telegraph electromagnets, which I did by the bridge discharge method, I found (as others no doubt have, also) considerable difficulty in obtaining and maintaining a stable zero from which to measure the discharge; this was owing, in the first instance, to the practical impossibility of obtaining exact balance except by means of a set of coils adjustable to small fractions of a unit, but more especially to the varying resistance of the electromagnet in the arm of the bridge, owing, no doubt, to the slight heating of the coils when traversed by the battery current. This perpetual variation became extremely worrying, but was overcome completely by the following simple device:—



FIGS. 1 and 2.

The magnet, r, whose coefficient of self-induction was required, was joined up as shown by fig. 1. K is a double key which, in its normal position, closes the battery circuit, *and also short circuits the galvanometer;* the contacts of this key are so set that on depressing the latter the galvanometer short circuit is opened a moment before the battery circuit. k is a supplementary key which enables the short circuit to be opened without opening the battery circuit. This latter key being depressed, the resistance, d, is adjusted until balance is obtained as nearly as possible on the galvanometer; the key, k, is then raised, and the galvanometer being thus short circuited the needle comes exactly to zero. On depressing key, K, the short circuit is opened, and immediately afterwards the battery circuit is broken, the result being that although exact balance may not be obtained as regards the four arms of the bridge, yet the interval between the opening of the galvanometer short circuit and the battery circuit is so extremely brief that the needle has no impulse given to it from this want of balance, but the throw which it receives is practically wholly due to the discharge from the electromagnet, r. After the throw due to the electromagnet has been observed a shunted condenser (fig. 2) is substituted and the throw with the same is also observed, then, as is well known, the coefficient, L, of self-induction of the electromagnet is

$$\mathrm{L} = \mathrm{F}\,\mathrm{R}^2\,\frac{d_1}{d_2}$$

when d_1 and d_2 are the throw deflections obtained in the two cases.

The resistances, r_1 and r_2 (which must have no self-induction), are used in order to enable that the throws in the two cases may not widely differ if the condenser, F, is not an adjustable one, but these resistances must be such that

$$r_1 + r = r_2 + \mathrm{R}.$$

It is evident that by increasing r_2 and diminishing R the portion of the discharge from the condenser which passes through the galvanometer can be reduced to any required extent. If it should happen that the discharge from the condenser when r_2 is equal to 0 is smaller than the discharge from the electromagnet, then we can diminish the latter by increasing r_1, R being of course increased so as to make $\mathrm{R} = r_1 + r$. Although, strictly speaking, the equation

$$\mathrm{L} = \mathrm{F}\,\mathrm{R}^2\,\frac{d_1}{d_2}$$

is only correct when

$$a\,d = b\,(r_1 + r),$$

yet the error due to d being slightly out is extremely small, and practically does not affect the correctness of the final result.

The method of measurement by taking two separate discharges first with the electromagnet and then with the shunted condenser is far better than an equilibrium method, *i.e.*, placing the electromagnet and shunted condenser together in series on one arm of the bridge, or one in one arm and the other in the other arm, and then adjusting till no deflection is observed on the galvanometer on depressing K; in fact, it is rarely that balance in such a case can be obtained, as it seldom happens that the discharges from the electromagnet and the shunted condenser take place in the same time (*i.e.*, their time constants are the same), consequently a kick is obtained on the galvanometer which no adjustment will get rid of, and which it is difficult to allow for.

Since the dimensions of F and R are $\mathrm{L}^{-1}\,\mathrm{T}^2$ and $\mathrm{L}\,\mathrm{T}^{-1}$ respectively, it follows that

$$\mathrm{F}\,\mathrm{R}^2 = \mathrm{L}^{-1}\,\mathrm{T}^2 \times (\mathrm{L}\,\mathrm{T}^{-1})^2 = \mathrm{L}$$

i.e., the coefficient of self-induction is a "length," but it may also be expressed

$$\mathrm{F}\,\mathrm{R}^2 = \mathrm{L}^{-1}\,\mathrm{T}^2 \times \mathrm{L}\,\mathrm{T}^{-1} \times \mathrm{R} = \mathrm{T}\,\mathrm{R}$$

i.e., time × resistance, and Prof. Ayrton has given to this unit the name sec-ohm (second-ohm).

Neither of these units, however, convey a definite notion to the practical worker and they are as indefinite to the latter as resistance would be if it were expressed in terms of velocity. The following would appear to be a much more practical method of expressing the self-induction.

In the case of a condenser, the quantity which the latter will take is equal to the difference of potential between its terminals multiplied by the capacity of the same; and this will be the quantity which the condenser will discharge irrespective of the resistance through which the discharge takes place, the resistance merely modifying the time. In the case of an electromagnet the conditions are different; here the quantity discharged will be inversely proportional to the resistance through which the discharge takes place, hence if we take as the starting point the quantity which will be discharged when the electro-magnet, or coil, is on short circuit, we can say that for any resistance, P, the discharge capacity, F_1, is

$$\mathrm{F}_1 = f\,\frac{r}{\mathrm{P}},$$

where f is the capacity.

The determination of f is a simple matter. If in the test just explained q_1 be the quantity discharged from the electromagnet and q_2 the quantity discharged from the shunted condenser, then

$$\frac{q_1}{q_2} = \frac{d_1}{d_2};$$

but

$$q_1 = \mathrm{v}\,f\,\frac{r}{\mathrm{P}}$$

where v is the potential between the terminals of the magnet. Also the quantity, q_2, which will be discharged from the shunted condenser will be

$$q_2 = \mathrm{v}\,\mathrm{F}\,\frac{\mathrm{R}}{\mathrm{P}}$$

where v is the potential between the terminals of the condenser; therefore

$$\frac{q_1}{q_2} = \frac{\mathrm{v}\,f\,r}{\mathrm{v}\,\mathrm{F}\,\mathrm{R}} = \frac{d_1}{d_2}.$$

But since the charging current in both cases is the same

$$\frac{V}{V} = \frac{r}{R},$$

hence

$$\frac{f}{F}\frac{r^2}{R^2} = \frac{d_1}{d_2}$$

or

$$f = F\,\frac{R^2}{r^2}\cdot\frac{d_1}{d_2}. \qquad (A)$$

If $R = r$ then

$$f = F\,\frac{d_1}{d_2}.$$

In an experiment made (amongst others) with the electro-magnet of a Siemens Morse inker (r = 400 ohms), the values of F_1 d_1 and d_2 were 7·25, 275, and 45 respectively, hence

$$f = 7{\cdot}25 \times \frac{275}{45} = 44{\cdot}3 \text{ mf.}$$

Supposing then we had the question asked—

What must be the capacity, F, of a condenser shunted with a resistance, R, of 1,000 ohms, in order that when placed in circuit with an electro-magnet of 44·3 microfarads capacity (f) and 400 ohms resistance (r) it may exactly counteract the discharge from the latter? From (A) we have by putting $d_1 = d_2$.

$$F = f\,\frac{r^2}{R^2} = 44{\cdot}3 \times \frac{400 \times 400}{1{,}000 \times 1{,}000} = 7{\cdot}09 \text{ mf.}$$

If the question is—

What is the discharge capacity (F_1) of an electro-magnet whose capacity (f) is 44·3 mf. and whose resistance (r) is 400 ohms, when the magnet is discharged through a resistance of 10,000 ohms (P)? then

$$F_1 = 44{\cdot}3 \times \frac{300}{10{,}000} = 1{\cdot}77 \text{ mf.}$$

If the magnet is charged to a potential of v volts, then the quantity, q, discharged will be

$$q = v\,F_1 \text{ coulombs.}$$

H. R. KEMPE.

REVIEW.

The Scientific Works of C. William Siemens, Kt., F.R.S., D.C.L., LL.D., C.E. A collection of papers and discussions. Edited by E. F. BAMBER, C.E. London: Murray.

In these three goodly volumes we find recorded the life-work of a mind of varied and wonderful activity. Among the numerous subjects to which the late Sir William Siemens turned his attention there were scarcely any upon which he did not throw some novel and valuable light, and not a few in which he effected advances of a very high order. Civil engineering, in the widest sense of the term, physics, astronomy, technical and scientific education, patent legislation, all shared his attention, and all are (or might be) the better for his exertions. The British Association, the Society of Arts, the Institution of Civil Engineers, the Societies of Mechanical and of Telegraphic Engineers, the Iron and Steel Institute, the City and Guilds of London Institute, all bear his activity in grateful remembrance.

The work before us consists of three volumes, the first comprising memoirs and discussions on heat; its production and its applications in metallurgy. The second volume is mainly devoted to electricity, and the third includes miscellaneous lectures and addresses. The principal electric subjects here discussed are the progress of the electric telegraph, the principles and practice involved in dealing with the electrical conditions of submarine lines, a machine for covering telegraph wires with India-rubber, the electrical tests employed during the construction of the Malta and Alexandria telegraph, and on the insulation and protection of submarine wires, the conversion of dynamical into electrical force without the aid of permanent magnetism, the feasibility of which was at one time strongly questioned.

In considering the superiority of iron over wood as a material for telegraph posts, attention is called to the fact that in hot climates the preparation of wood with sulphate of copper or with creosote adds little to its durability. Indeed, in forests and deserts the telegraph and telephone, if aerial, have many enemies. In India and South America the monkey population seem to think that posts and wires are put up solely for their gymnastic performances. Whilst in Norway and Russia the bears, deceived by the humming sound often given off, fancy that a nest of wild bees must exist somewhere about the base of the supports, and consequently uproot them in order to get at the honey.

As to underground wires, it is possible that they might be quite as seriously interfered with by fungi, insects, and burrowing mammals.

Further subjects dealt with are the steamer *Faraday* and her appliances for cable laying, the dependence of electrical resistance on temperature, the measurement and regulation of electric currents, the transmission and distribution of energy by the current, methods to improve the steadiness of the current, and a contribution to the history of secondary batteries.

A subject to which Sir W. Siemens devoted much attention was the application of electric energy to horticulture. On this subject no very decided progress has since been made, and it is possible that Sir W. Siemens was a little too sanguine in his expectations. He fully saw that the production cost of the electric light, until great improvements have been effected, must set a serious limit to its horticultural use, save for articles of luxury. He also satisfied himself that a naked arc light in a conservatory or forcing-house exerted injurious effects, even to a distance of 20 feet. This mischief seems due to the fact that the arc light differs in its composition from sunlight, containing a larger proportion of highly refrangible, but invisible rays. These rays seemed to be the cause of the mischief, for when a sheet of clear glass (which largely intercepts this class of rays) was interposed, the destructive action ceased.

It can only be concluded that we have here a subject which demands and deserves closer scrutiny than it has yet received.

Of the supposed beneficial action of electric currents upon vegetation if passed into the soil or through the atmosphere Sir W. Siemens makes no mention, and later experimentalists pronounce this idea a complete mistake.

Great attention was drawn to a paper here inserted and which appeared in the proceedings of the Royal Society in 1882. Its subject was the "Conservation of Solar Energy." Although it does not, like most of the labours of its author, deal with a technical subject, it evinces wonderful originality and intellectual grasp, and though it deviates from the orthodoxy of solar physics, it can by no means be set aside as exploded. A discussion of the process by which the author supposes the apparent waste of energy in the sun and in kindred bodies is compensated, would fall outside our limits.

Turning to a totally different subject, the telegraphic connection between Britain and India, we can scarcely accept the contention of Sir William Siemens that our intercourse with India by the land line would be uninterrupted even in the case of a Russian war. In such a contingency Russia might think it more advantageous not to cut the wire but to "tap" it, and use the information thus obtainable to our disadvantage.

In a discussion on the construction of heavy ordnance, we note the following pregnant saying:—"Mathematics, however good a handmaiden, might be a very dangerous master."

The author's views on patents are in the main satisfactory. He fails to see, or at least to notice the two great faults in our present patent system, *viz.*, the want of

an imperial patent, covering the whole of Her Majesty's dominions and obtainable, according to the convenience of the inventor, either in London, Calcutta, Sydney, Cape Town, Toronto, or as might be agreed on. The second fault is that an alien, resident abroad, may take out and uphold a British patent without any intention to work it on British ground, but simply to prevent anyone else from so doing.

We must here, however, cut short our examination of this most valuable work, to which space allows us to do but scanty justice. It would be a sin of omission on our part did we not mention the admirable index with which each volume is furnished.

Transactions of the American Institute of Electrical Engineers. Vol. V. Published by the Institute, 5, Beckman Street, New York.

This volume is full of interesting matter, the general contents being as follows:—"On Electric Street Cars, with Special Reference to Methods of Gearing," by A. Reckenzaun; "A Coulomb-Meter, or Instrument for Measuring the Consumption of Electricity," by Prof. G. Forbes; "Recent Improvements in Apparatus for Ocean Cabling," by Ch. Cuttriss. Supplementary note on the "Siphon Recorder and Cable Telephony," by T. D. Lockwood; "Phenomena of Retardation in the Induction Coil," by W. Stanley; "Electric Energy from Carbon without Heat," by W. E. Case; "Alternating Current Electric Motors," by Dr. L. Duncan; "The Maximum Efficiency of Incandescent Lamps," by J. W. Howell; "Protection of the Human Body from Dangerous Currents," by P. B. Delany; "The Possibilities and Limitations of Chemical Generators of Electricity," by P. B. Crocker; "Compensated Resistance Standards," by Prof. E. L. Nichols; "A New System of Alternating Current Motors and Transformers," by N. Tesla; "Underground Electrical Conductors in Europe and America," by G. W. Plympton; "A Swinging Arm Galvanometer," by G. H. Stockbridge; "The Solution of Municipal Rapid Transit," by F. J. Sprague; "Some Objections to the Overhead Conductor for Electric Railways," by M. B. Leonard; "Note on Gearing for Electric Railway Motors," by A. Robinson. Nearly all these papers have appeared in our columns.

The Victorian Electrical and Telegraphic Journal. February, 1889, Melbourne.

This journal, which has now reached the 31st No. of the third volume, continues to flourish, though necessarily the amount of matter given is not great, the quality is, however, good.

THE EFFICIENCY OF METHODS OF ARTIFICIAL ILLUMINATION.*

By EDWARD L. NICHOLS, Prof. of Physics in Cornell University.

OF human industries of the present day none perhaps, save those which have to do with providing the race with food, clothing, shelter and fuel, is more important to the cause of material welfare than that which deals with the production of artificial light, and he who seeks a means of measuring the material civilisation reached by a nation might find an excellent criterion in the progress which it exhibits in the art of illumination.

The problem of comparing the various methods of artificial lighting which are in vogue at the present day is one of great interest, whether we view it from the commercial standpoint, taking the cost of production as our controlling factor, or from the broader basis of relative usefulness, cost being relegated to a secondary position, or, finally, from the purely scientific point of view. From whichever side we approach this question, we are led inevitably to the consideration of certain elements which are alike of scientific, utilitarian and commercial importance.

At first sight the attempt to determine the relative value of two sources of light would seem to be a simple matter. The number of factors, however, which enter into such a determination is surprisingly large, and many of them are of a character which makes it difficult to give them definite and complete expression. Of these the greater part are indeed commonly left out of account altogether for the sake of simplicity, and we content ourselves with an antiquated and totally insufficient measure of our sources of illumination, which we call candle-power. It is to these other elements which enter into the question of the character of artificial light—such, for instance, as have to do with its *quality*—but which are, as a rule, quite lost sight of, to which I would ask your attention this evening, together with a discussion of those which are commonly made use of in photometry. If, in so doing, I am led to speak of methods which belong to the realm of pure science, I trust that you will agree with me in thinking that the results are not unimportant even to those whose interest in the problem of the production of artificial light is purely utilitarian.

In the important question of the efficiency of a light-producing machine or process, the practice of to-day is very far from having reached that degree of exactness of expression which we demand in other cases of the transformation of energy. In electric lighting the energy expended is readily determined in absolute measure, or in that excellent practical unit, the *watt*. In lieu of any attempt to express the useful energy obtained, however, we still content ourselves in practice with that most unscientific unit, the candle-power, based upon a source of illumination which is particularly subject to fluctuations of intensity and colour. Even as used in the Bunsen photometer the shortcomings of the standard candle are sufficiently apparent, but no one who has not attempted to study it by methods which make it possible to detect changes of colour as well as of brightness, can fully appreciate its fickleness.

Such as it is, we do not, moreover, make the best of the standard candle as a basis of comparison of artificial lights. We speak of a 16-candle incandescent lamp, for instance, meaning oftentimes "mean spherical candle-power," and then we compare it with a petroleum or gas flame, measured in the horizonal plane only, much to the disadvantage of the electric lamp. The study of the distribution of intensities in accordance with the very complete system devised for that purpose by the Franklin Institute Committee in 1884, affords an invaluable means of comparing the performance of various types of incandescent lamps; but the adoption of "mean spherical candle-power" as obtained by that method is, to say the least, misleading when it comes to the comparison of electric lamps with candles, oil, or gas. It is to be hoped that when the present confusion of methods of measuring candle-power now existing in the electric lighting establishments in this country is supplanted by a recognised system, the fairer standard already established by law in England, viz., mean horizontal candle-power, may be adopted. It is, however, in the comparison of arc and glow lamps that the latter are put at the greatest disadvantage. Here we pit the incandescent lamp, using mean spherical candle-power as our basis, against candle-power measured at the angle at which the arc light sends out the greater part of its rays. Indeed, in too many cases, it is not with the actual intensity even in this most favourable position with which we have to do, but with an estimated or "nominal" candle-power which the arc, in matter of fact, never approaches.

The electric arc stands quite alone, for the purposes to which it is adapted, and need fear no rivals. It does not need to be estimated upon any fictitious basis, and the continuance of the pernicious practice of ascribing to it powers of illumination which it does not possess

* A paper read before the American Institute of Electrical Engineers, March 12th, 1889.

must, in a great measure, be charged to the account of the standard candle; for with the best intentions in the world, the comparison of sources of light differing so widely in colour as the candle and the electric arc, is nothing more than a rude approximation, leading by its very inaccuracy to the temptation of the grossest exaggeration.

There are fortunately better methods of estimating the efficiency of a lamp than that which is based upon candle-power.

We may, for instance, determine the ratio of the energy of the light-giving radiation to that of the total radiation of the source of illumination. The efficiency of the incandescent lamp, according to this definition, has been recently determined by Mr. Ernest Merritt,* of the Physical Laboratory of Cornell University. Mr. Merritt followed two independent methods of investigation. In his first experiments the lamp was placed in a calorimeter constructed entirely of glass, fig. 1,

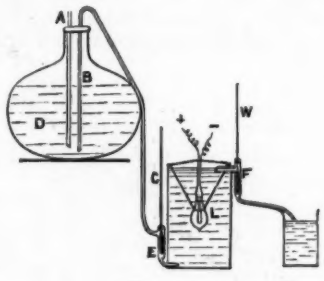


FIG. 1.

through which a constant flow of water was maintained. The temperature of the water upon entering and upon leaving the calorimeter was measured by means of the thermometers, E and F. From this difference of temperature and the amount of water discharged in a given time, the heat absorbed by the calorimeter was calculated, proper corrections for loss of heat by radiations, &c., being applied. Now the water with which the calorimeter was filled is nearly transparent to the light-giving radiations from the lamp, and almost entirely opaque to the longer wave lengths which constitute the so-called heat spectrum. To have assumed it to be entirely so would, however, have involved very considerable errors, and the diathermancy of the calorimeter on the one hand and its power of absorbing the luminous wave lengths on the other, were accordingly carefully determined by methods long since elaborated and made use of by Melloni and by his distinguished English follower, Prof. Tyndall. By applying these and other necessary corrections we are able to calculate very accurately in watts the non-luminous radiation from the lamp. The ratio of the total radiation, obtained either by submerging the lamp in a metallic calorimeter or by direct computation from the current and electromotive force gives the actual efficiency of the

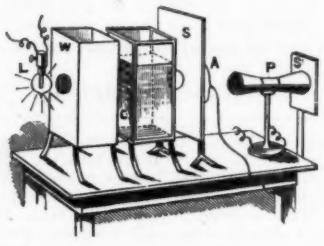


FIG. 2.

lamp considered as a light-making machine. The result is not a gratifying one, when we compare this process with most others in which energy is transformed. The efficiency of the best types of incandescent lamps, previous to the introduction of the recent 3 watts per candle lamps now in successful operation, which would doubtless make a somewhat better showing, was found to be rather under than over 5 per cent. at normal candle-power; the values ranging from 5 per cent. to 6·5 per cent. The last named value for the efficiency was attained only at a temperature incompatible with any considerable length of life. The results obtained in this investigation are shown in Table I.* and in the accompanying diagram, fig. 3.

TABLE I.†

Lamp A. Edison.

E.M.F.	W.	C.P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
74·2	34·6	0·9	0·18	0·005	0·59
91·6	56·2	4·8	0·68	·012	0·14
97·3	64·6	7·3	1·13	·017	0·15
100·3	69·3	8·9	1·62	·023	0·18
107·6	81·6	14·6	2·97	·036	0·20
109·3	84·4	16·3	4·57	·054	0·28
124·1	115·4	38·2	7·46	·035	0·19

In this table W is the total energy in watts; L the energy of the light, also measured in watts; and C.P. the candle-power.

The second method pursued by Mr. Merritt was intended rather as a check upon the results already obtained than in the expectation of gaining further data. The rays of the lamp were allowed to fall upon the face of a delicate thermopile placed at a distance of about 60 cm. The thermopile was in circuit with a low resistance galvanometer of the well-known "tripod pattern" of Sir William Thomson. The deflection of the galvanometer was taken as a measure of the total radiation, luminous and non-luminous, which fell upon the face of the pile. A cell containing a solution of alum was now interposed, and the reduction in the galvanometer noted. The arrangement of this apparatus is shown in fig. 2.

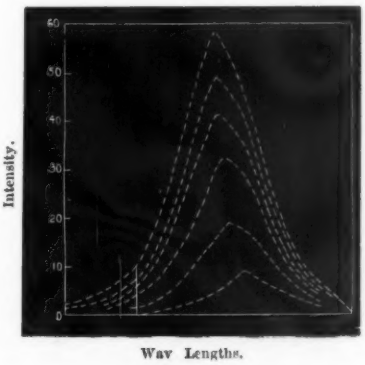


FIG. 3

As aqueous solution of alum fulfils much more nearly the desired condition of complete opacity to "dark heat" and complete transparency to the rays of the visible spectrum than any other substance, but a certain small percentage of the longer wave lengths will pass through such a bath, and a considerably larger percentage of light-giving rays will be cut off by it

* Ernest Merritt, *American Journal of Science*, vol. 37, p. 167

* Dr. Blattner in an Inaugural Dissertation, published at the University of Zürich, gives similar values for the efficiency of the incandescent lamp. He finds, as the result of extended measurements with the glass calorimeter, that . . . "at the normal temperature of incandescence, where the intensity lies in the neighbourhood of 16 candles, the efficiency does not rise above 5 per cent. to 6 per cent."—Emil Blattner: *Der Optische Nutzeffect der Glühlampen*, Frauenfeld, 1886.

† Tables I. and II., and figs. 1 and 2, are taken from Mr. Merritt's paper, already referred to.

The proper corrections are, however, easily determinable, and when in this case they had been determined and applied, the ratio of total to luminous radiation was found to be in gratifying agreement with the efficiency obtained by the calorimetric method already described. See Table II.

TABLE II.

Lamp B.

An Edison 16 C.P. lamp. Resistance = 249 ohms.

E.M.F.	W.	C.P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
63·0	25·4	0·3	0·42	0·016	1·61
74·6	37·8	1·0	0·77	·021	0·79
85·4	52·5	2·5	1·96	·037	0·78
99·0	72·2	6·3	4·30	·059	0·68
116·0	102·0	15·2	7·38	·072	0·49

Lamp C.

Weston 16 C.P. Cold resistance = 402 ohms.

E.M.F.	W.	C.P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
72·0	21·6	0·4	0·46	0·021	1·27
87·4	33·5	1·5	1·10	·033	0·76
102·0	47·8	4·4	2·09	·044	0·48
117·0	66·1	10·7	3·19	·048	0·30

Lamp D.

Weston 16 C.P., 70 volt. Resistance = 152 ohms.

E.M.F.	W.	C.P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
43·0	25·8	0·5	0·53	0·021	1·06
50·7	36·0	1·6	0·97	·027	0·62
60·5	52·0	5·2	2·03	·039	0·39
67·5	65·5	11·0	3·95	·060	0·36

Lamp E.

Bernstein 8 C.P. Resistance = 11·3 ohms.

E.M.F.	W.	C.P.	L.	$\frac{L}{W}$	$\frac{L}{C.P.}$
12·2	25·2	0·2	0·20	0·008	1·00
13·4	30·8	0·5	0·41	·013	0·84
15·0	40·4	1·3	0·75	·018	0·57
16·4	53·2	4·1	2·03	·038	0·50

It is interesting to compare these results with some obtained by still another method. Captain Abney and Colonel Festing in the Proceedings of the Royal Society have described a series of elaborate studies of the radiation of the incandescent lamp. The portion of their very important investigation which has a bearing upon the efficiency deals with the exploration of the spectrum of the lamp, under various degrees of incandescence, by means of an exceedingly sensitive thermopile. The energy of the visible spectrum of most sources of light is so minute that it has generally been deemed impracticable to measure it in this way. Captain Abney and his co-worker have, nevertheless, secured measurements covering not only the extensive regions of the so-called heat spectrum lying inside the red, but also the shorter wave lengths which constitute the visible spectrum. Their results are shown graphically in fig. 3.

One of the British Electric Company's lamps was subjected to measurements in six different states of incandescence, corresponding to 33·6, 60·2, 93·8, 116·4, 130·8 and 150·5 watts repectively. The curves show the intensity of each wave length of the spectrum, when the above amounts of energy were expended in the filament, and the total area inclosed by each curve affords a relative measure of the total radiation of the lamps in the state of incandescence in question. I have added to this diagram, of which, in other respects, fig. 3 is a faithful reproduction, the vertical line lying between scale divisions 5 and 6 of their scale. This line marks the boundary between the visible and invisible spectrum. The entire area to the right of that line represents the energy wasted in the lamp; the much smaller area to the left comprises the light-giving rays. The ratio of the entire area of each curve to that portion lying within the boundaries of the visible spectrum gives us the efficiency of the lamp for the state of incandescence produced by the expenditure of the number of watts for which the curve is drawn. This ratio increases from a very small value with the brightness of the lamp.

I have made approximate integrations of the areas embraced by the curves for 150·5 and 130·8 watts, respectively, for the purpose of comparing the efficiency thus calculated with the results obtained by Mr. Merritt. The ratios are :—

Watts.		Efficiency.
150·5	...	5·55 per cent.
130·8	...	5·15 ,,

The corresponding values for lower states of incandescence are all smaller than the above.

It will be seen that these results are in complete agreement with those obtained with the glass calorimeter and by the method of Melloni. We have, indeed, reason to feel that our knowledge of the absolute efficiency of the incandescent lamp, in so far as it can be expressed by the ratio of luminous to total radiation is well grounded, and that we are in a position to determine the light-giving efficiency of any type of glow lamp in any condition of incandescence with the same certainty and exactness which is attainable in the measurement of other machines for the transformation of energy.

The average net efficiency of the incandescent lamps of to-day, for we may leave untouched for the present the efficiency of the processes by which the latent energy of fuel from which the current is generated has been converted into electrical energy, is rather below, than above, 5 per cent., and since the ratio of total radiation to light-giving radiation increases but slowly as the temperature of the radiating body rises, the efficiency is not likely to be increased in any very marked degree until we shall have learned how to suppress altogether these long wave lengths which yield us dark heat, and are able to limit the vibrations of our source of light to that brief octave which comprises the wave lengths to which alone the human retina responds.

Whether this great step is to be made by robbing the glow worm and fire fly of their secret, as has been suggested in a recent address by the Director of the Sibley College of Mechanical Engineering,* or by development along the lines sketched the other evening by Prof. Brackett at the meeting of the Electric Club, or by the application of some principle as yet unconceived, we know not. Meantime, we have in the methods of artificial lighting of to-day abundant material for study and investigation.

The investigation of the efficiency of the arc light by

* "The second of these greatest of inventors is he who will teach us the source of the beautiful soft-beaming light of the fire-fly and the glow worm, and will show us how to produce this singular illuminant, and to apply it with success practically and commercially. This wonderful light, free from heat and from consequent loss of energy, is nature's substitute for the crude and extravagantly wasteful lights of which we have, through so many years, been foolishly boasting. The dynamo-electrical engineer has nearly solved this problem. Let us hope that it may be soon fully solved, and by one of those among our own colleagues who are now so earnestly working in this field, and that we may all live to see him steal the glow worm's light, and to see the approaching days of Vril predicted so long ago by Lord Lytton." —ROBERT H. THURSTON—*Transactions of the American Society of Mechanical Engineers*, 1881, p. 22.

the methods under consideration is a much more difficult matter than the same determination in the case of the incandescent lamp. The radiating surface of the latter is very nearly of the same temperature throughout, and the ratio of total radiation to luminous radiation, obtained for the bundle of rays sent out in a single direction, gives us at once the measure of the efficiency. In the arc we have, however, a light-giving area of great brilliancy in the immediate neighbourhood of the arc, and the temperature of the carbons falls with great rapidity from the maximum at the point and crater to regions which are at a red heat.

The entire light-giving area is included between the line surrounding the positive carbon, which is at red heat, and the corresponding line upon the negative carbon. Between these two lines we pass rapidly through regions the light from which varies with the degree of incandescence by insensible gradations from that which a red hot surface is capable of emitting to that coming from carbon at the highest temperature which that substance can be made to assume. Now, the curve of distribution of candle-power taken in a vertical plane is, as we all know, a very peculiar one, and if we place our thermopile with alum cell interposed to measure the energy of the light-giving rays, the amount of radiation received upon the face of the pile will greatly depend upon the position in which the apparatus is set up. At an angle of 45°—or 50° below the horizontal plane, for instance—the amount indicated will be five or six times greater than in the horizontal plane. Now, the surface of total radiation is much larger than that from which the light-giving rays emanate. It includes, in addition to the incandescent surfaces near the arc, all those portions of the carbons which are heated either by conduction or by the current.

The amount of heat radiated from regions which are below the red heat is very considerable, and forms an important factor in the determination of the efficiency. Were the distribution of total radiation in the vertical plane identical with that of the light-giving rays, the measurement of their ratio with the axis of the thermopile in any plane which passes through the arc, would give us the efficiency of the lamp; but the curve of distribution of total radiation is not the same as that of candle-power, and the ratio in question is a function of the plane which the axis of the pile makes with the horizon. It becomes necessary, therefore, to make an exploration of the entire zone through which the lamp sends out rays, determining the ratio of total to luminous radiation for each angle, and then to integrate the results. Such an investigation is now in progress under my direction, and Mr. H. Nakano, who is carrying on the experiments, has reached some exceedingly interesting results. The research will soon be ready for publication in its complete form, and it will afford us much more definite data concerning the radiations of the electric arc than we now possess. It will not be out of place even now to say a word concerning the method which is being employed, and the general character of the results already obtained.

The first measurements were made by the second method employed by Mr. Merritt, the thermopile in the horizontal plane. The lamp subjected to measurement was of the long arc type, with 9 ampères of current and 45 volts. The efficiency in this plane was found to be surprisingly small. It was found, moreover, to vary in marked degree with the diameter of the carbons used, increasing as the diameter decreased to the point at which the carbons were rendered hot by the current, when, as might be expected, it fell off again.

The lamp was then mounted in a frame which also carried the thermopile and alum bath, and which was so constructed that measurements could be made at any desired angle. All necessary changes of angle could be made without varying the distance from the arc to the face of the pile, or the relation of the alum bath to the latter. By means of this apparatus, which is shown in fig. 4, it has been found possible to determine the ratio of total to luminous radiation throughout the zone of radiation of the lamp, and to plot the curve of distribution of each.

Without entering into the details of an incompleted research, I may indicate the general character of the

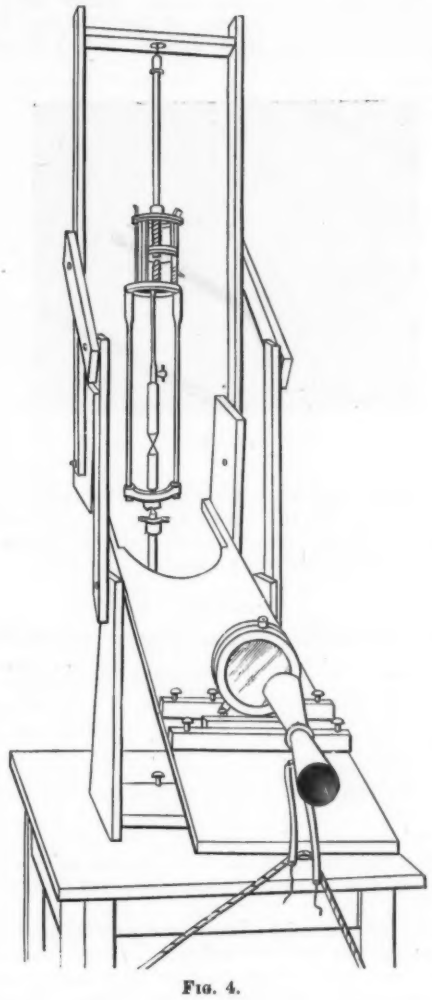


FIG. 4.

results by means of a diagram. The curves shown in figs. 5 and 6 are those relating to a "long-arc" lamp with carbons ·45 inch in diameter. They represent respectively the distribution of luminous and total

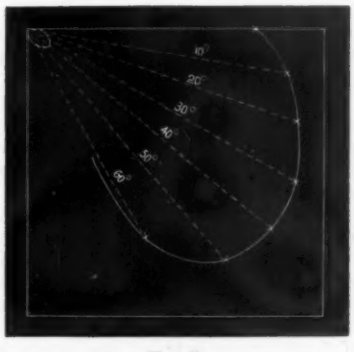


FIG 5.

radiation emanating from the lamp. The radii show the positions for which measurements were taken; distances measured along these lines from the origin to each curve give the relative intensities of light-giving and total heat energy in each position.

The curve of luminous radiation corresponds in form with that of candle-power. The distribution of total radiation, however, differs widely from these and the ratio, $\frac{\text{luminous energy}}{\text{total energy}}$, is a function of the angle which the line of measurement makes with the horizontal plane. The values of the efficiency in the case in question for the various angles at which

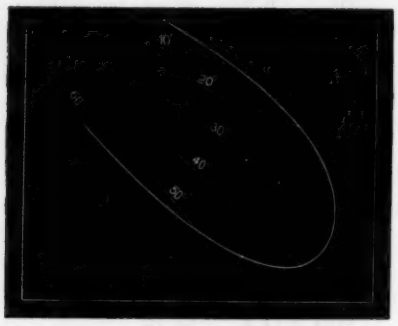


FIG. 6.

measurements were made are given in Table III. They form the basis for the curve in fig. 6, which is the diagram of efficiencies of the arc light under the conditions of operation already stated.

TABLE III.

Efficiency of an arc lamp; after measurements by Mr. H. Nakano.

Angle.		Efficiency = $\frac{\text{Luminous radiation}}{\text{Total radiation}}$.
0°	...	·0548
10°	...	·0901
20°	...	·1228
30°	...	·1506
40°	...	·1552
50°	...	·1059
60°	...	·0676
63°	...	·0492

The integration of these values gives as the mean efficiency of the arc lamp in question, ·104; or 10·4 per cent.

The ratio of the radii of two semi-circles, the areas of which equal the areas enclosed by the curves of luminous and total radiation, gives us a measure of the "mean spherical" efficiency of the lamp. This ratio in the case of the lamp to which these curves refer is very much smaller than the generally accepted values of the efficiency of arc lamps, expressed in terms of the candle-power per watt, would lead us to expect. The intensity of the arc is, however, seldom expressed in mean spherical candles, and there are few data relating to the candle-power of this source of light upon which to found satisfactory estimates. On the one hand we find it stated, doubtless correctly, that the mean light-producing efficiency of the eleven dynamos, tested at the International Health Exhibition, held in London in 1884, was 1,440 candles per horse-power,* while the glow lamps only yielded 175 candles, and it is with estimates similar to the above with which we have generally to satisfy ourselves in comparing arc and incandescent systems of illumination.

For the purpose of deciding whether the results of Nakano's method of determining the ratio of luminous to total radiation are compatible with our other sources of knowledge concerning the arc light we must make use of mean spherical candle-power as our basis of comparison.

Very careful measurements of the mean spherical candle-power of two arc lamps of representative and successful commercial types were made in the physical laboratory of Cornell University,† following the method of the Franklin Institute Committee. Both of these lamps were rated at 2,000 candle-power. They were maintained by dynamos of the types for which they had been especially designed, working under normal conditions. One of the lamps gave a mean spherical candle-power of 295, when working in series with nine other lamps of the same construction. When placed in circuit alone, the candle-power rose to 348. The energy expended in the lamp in each case was 550 watts, and the efficiency accordingly 1·8 watts and 1·6 watts per candle.

The other lamp was found to reach 609 mean spherical candles at the cost of 601 watts. An inspection of the result obtained by the Franklin Institute Committee would lead us to regard these as extreme values, between which the performance of almost all arc lights would lie, as a rule, nearer the lower than the upper of these limits. The efficiency of arc lights, then, expressed in mean spherical candle-power per watt is frequently as low as 1·5 times that of the incandescent lamp, and, rarely, three times as high. Now the mean efficiency of the arc lamp under discussion, *i.e.*, the ratio, $\frac{\text{luminous radiation}}{\text{total radiation}}$, according to the measurements of Mr. Nakano, is almost exactly 10 per cent. The efficiency of incandescent lamps, defined in the same way, according to Mr. Merritt, may, as we have seen, be taken at about 5 per cent. The ratio is 2 : 1 in favour of the arc lamp, which lies within the limits determined by comparison of candle-power and watts.

Small as these values for the efficiency of the electric light are, they show marked improvement over the efficiency determined in a similar manner for sources of illumination which depend upon the incandescence of carbon by direct combustion. More than a quarter of a century ago, Julius Thomsen * presented before a gathering of Swedish men of science, the results of an investigation of the energy consumed in the sperm candle, and in various oil and gas flames. His memoir bore the suggestive title of the Mechanical Equivalent of Light, and is one of the earliest contributions to our knowledge of the energy of luminous radiation.

The instruments employed in Thomsen's experiments were the thermopile and galvanometer, the indications of which were reduced to absolute measure by determination of the deflection produced by the radiation from a glass globe filled with hot water. The total loss of heat by radiation which this globe suffered was calculated from its rate of cooling, using Dulong and Petit's law. The water equivalent of the globe was 1,351 grains; its total loss of heat per minute at 50° C. was 250 calories; its loss of heat by radiation at the above temperature, when the air of the room was at 17 degrees, was 102 calories per minute. Under these conditions the influence of the globe of water upon the thermopile placed at a given distance was observed. A luminous body having been substituted for the globe, its influence on the pile was likewise noted, and its total radiation in calories calculated by comparison of the deflections produced in the two cases.

For a sperm candle burning 8·2 grains per hour, the total radiation estimated by this method was 210 calories per minute. Other flames gave out quantities of heat nearly in proportion to their candle-power, as will be seen by inspection of Table IV.

TABLE IV.

Calories per candle-power radiated by various flames, according to Julius Thomsen.

Source of illumination.	Candle-power.	Calories per candle.
Sperm candle	1· ...	210
Gas flame	1·2 ...	201
Gas flame	7·7 ...	199
Moderator lamp	8·6 ...	199

The luminous energy was obtained by a method similar to that pursued by Merritt in the experiments already described. A bath containing a layer of water

* Julius Maier: Arc and Glow Lamps, p. 52.

† *The Photometry of Arc Lights.* Thesis by Benjamin W. Snow, 1885. MS. in the Library of Cornell University.

* Julius Thomsen: Das Merchanische Æquivalent des Lichtes: *Poggendorff's Annalen, Bd.* 125, p. 348.

20 c.m. in thickness was interposed between the lamp and the thermopile, and the indications of the galvanometer noted. The results were based upon the assumption that the cell absorbed 13 per cent. of the light and all of the dark rays. This estimate is doubtless faulty and may involve a reduction of several per cent. from the values given by Thomsen. His results, uncorrected, are as follows :

TABLE V.

Energy of luminous radiation of various flames in calories, according to Julius Thomsen.

Source of illumination.	Candle-power.	Luminous energy per C.P.
Candles	1· ...	4·4 calories.
Moderator lamp ...	6·25 ...	3·9 ,,
Moderator lamp ...	8·6 ...	4·1 ,,
Gas	7·7 ...	4·2 ,,
Gas	1·2 ...	3·7 ,,

The energy of the light-giving rays per candle-power of light produced is then, according to Thomsen, very nearly the same for the flames of the candle, oil lamp and gas burner. This conclusion has been abundantly confirmed by spectro-photometric observations of the quality of the light which they emit. It appears, moreover, from these observations, of which I shall have occasion to speak at length presently, that the temperature of the incandescent particles in such flames agrees very closely indeed with that of an incandescent lamp, consuming 5 watts at 16 candle-power, being, as a rule, lower, rather than higher, than the latter ; and the calculation of the energy of such a lamp in calories per minute, making use of the data furnished us by the investigation of Abney and Festing, or of Merritt, affords most satisfactory evidence of the accuracy of Thomsen's results. Let us take for example the case of an incandescent lamp in which 5 watts per candle-power are expended, and in which the ratio,

$$\frac{\text{Luminous radiation}}{\text{Total radiation}} = \cdot 05$$

The energy converted into light in such a lamp is ·25 watt.

Now,

1 gramme-calorie = $4{\cdot}2 \times 10^7$ ergs.

1 watt = 10^7 ergs = $\frac{1}{4{\cdot}2}$ gramme-calories per second.

·25 watt = $\frac{{\cdot}25 \times 60}{4{\cdot}2}$ gramme-calories per minute and the heat equivalent of the luminous energy is 3·6 gramme-calories per minute.

This value is somewhat smaller than those given by Thomsen in the preceding table, but proper corrections for the diathermancy of the water bath used in his experiments and for the difference in standards of candle-power—the light given by his sperm candle being slightly in excess of the legal standard of the present day—will bring the two into excellent agreement.

(*To be continued.*)

STORAGE BATTERY LITIGATION.

THE decision given by Judge Coxe in the United States Circuit Court of New York, in the case of the Electrical Accumulator Company *versus* the Julien Electric Company, must be regarded as a serious blow to the plaintiffs, who have done their best to create a monopoly in the storage battery industry. The action was for the infringement of four letters patent owned by the complainant for an improvement in secondary electrical batteries. One of these, granted to Shaw and Rogers in 1882, has been withdrawn from the consideration of the Court. The other three in controversy comprised one of Camille Alphonse Faure, dated January 3rd, 1882, and two of Joseph Wilson Swan, dated February 17th and May 26th, 1885. The case has been pending for two years or more, during which time an immense amount of testimony has been taken in all parts of the world. "The defendants," said the Judge, "have introduced an immense number of exhibits, which show the steady evolution in batteries, both secondary and primary. As to the vast majority of these, it is not pretended that they anticipate. They may be interesting from a scientific standpoint, but they shed little light upon the issues in controversy, and rather tend to confuse them. In order to determine who shall be rewarded in the race for invention, it is not essential to note the efforts of those contestants who have dropped out during the first half of the contest. Those who reach the goal are to be considered, and the one reaching it first is entitled to the prize. It is only necessary, therefore, to examine those exhibits which show the closest approximation to Faure's invention."

The plaintiffs left not a stone unturned to make out a good case, and M. Faure was called from Paris to New York 18 months ago, and he has, at the expense of the Accumulator Company, waited patiently for the arrival of this contest, which has only just been decided.

The inventor, Faure, describes the secondary batteries of Gaston Planté, in which, by a long and expensive operation, involving weeks, and even months, the plates are formed with a comparatively limited capacity. To prevent this waste of time and money, and to construct a more powerful battery, was Faure's object. His electrodes are made, not by the formation of a porous layer by disintegration in the body of the metallic plates, but by adding to suitable supports a layer of active material of the desired depth, in the form of a paint or paste, or otherwise, which is, or at once becomes, spongy or porous. This active layer may be rendered more porous by mixing with the material composing it some inert material such as crushed coke. "In charging, the electricity acts to produce a reduced mass of porous lead on one electrode, and a mass of peroxide of lead on the other. When the battery is discharged the reduced lead becomes oxidised, and the peroxidised lead is reduced until equilibrium is restored." The claims in controversy are the first and fourth in the American specification. They are : "1st. As an improvement in secondary batteries, an electrode consisting of a support coated on one or more faces with an active layer of absorptive substance such as metal or metallic compound, applied thereto in the described condition, so as to be, or instantly become, spongy, and thus capable of receiving and discharging electricity as stated, in contradistinction to a metallic plate itself rendered spongy by the disintegrating action of electricity, substantially as and for the purpose set forth. 4th. In a secondary battery a series of cells, comprising each a pair of electrodes with an active spongy layer thereon, combined with non-porous partitions between adjacent cells, substantially as and for the purpose set forth."

The general defence is want of novelty, which is subdivided as follows :—

First. Prior use.

Second. Anticipation in prior patents and publications.

Third. Public use more than two years prior to the application.

Fourth. Lack of invention.

Fifth. The claims are too broad, and include well known prior inventions.

Sixth. The patent is ambiguous and misleading, and does not point out the inventions.

Seventh. The original application was unlawfully expanded by amendments.

Judge Coxe said : "That the language of the patent is ambiguous, and especially so as it relates to the first claims, seems to be conceded on all hands. If other proof were needed that it is not written in the most perspicuous language, it will be found in the fact that the record contains nearly 2,000 pages, the greater part of which, as well as the briefs which

aggregate 411 pages, is devoted to an effort to ascertain its meaning, an effort which has hardly crystallised into a demonstration upon any one of the points in controversy."

The patent is not specific upon the question, whether or not the absorptive substance shall be insoluble in the battery fluid. It was thought that the language of the patent, although by no means clear, can hardly be construed to exclude a coating soluble in the electrolyte. Why the patentee, having invented a practical, efficacious and meritorious method, should have used language which apparently includes an inferior and comparatively useless one, is indeed inexplicable. That it was intentional can hardly be imagined. Among the host of evidence introduced by the defendants, was a prior publication in the *Electrician* of 1863, entitled "Secondary Batteries," in which the writer describes a negative element of platinum or lead, surrounded by a mixture of dilute sulphuric acid and peroxide of lead, and a positive element of amalgamated zinc in dilute sulphuric acid. The article is not illustrated by drawings, the descriptions are somewhat vague and general, and there is no evidence that a successful secondary battery, having the characteristics mentioned, was ever made; on the contrary, structures quite similar were proved to be inoperative and valueless.

The report of the Smithsonian Institution for 1856 describes a secondary battery of any number of platinum plates. Platinum black had been deposited thereon electrolytically, producing a microscopical film of finely divided platinum of a thickness "not far from the hundredth part of thin paper." Though the operator obtained a better result with the plates thus created than when they were bright, he seems to have been oblivious as to the reason therefor.

Kirchoff's United States patent of 1861 describes a battery, each cell of which contains a pair of platinum electrodes. The cells contain a solution of salts of lead. Upon being connected with a charging battery "the negative electrode will turn black peroxide of lead, and the positive electrode will be surrounded by crystallised lead. By changing the proportions of the substances of the solution more or less peroxide of metal will be deposited, and the conducting power, &c., may be increased or decreased in the same ratio." This would seem to describe a secondary battery with two initially similar plates, both coated by the charging current with a layer of active material.

Planté, too, described in 1872 his attempts to produce a thicker layer of peroxide of lead by galvanic deposit at the expense of the liquid.

The idea of Percival, in 1869, also as shown in his United States patent, was to improve on Planté's method by saving time and expense. He describes a secondary battery consisting of one pair of electrodes placed in a watertight wooden box, divided in its centre by a porous partition. On each side of this partition is a layer of powdered gas carbon. These layers constitute the two electrodes, and when in use they are wetted by a proper solution. "Lead or any other suitable metal in form of coarse powder may be substituted for the gas carbon." This appears somewhat analogous to some of the forms described by Faure. The complainant contends that the reference is valueless for the reason that there is no suggestion of a conducting support plate like Faure's which holds the active layer and conducts electricity to each and all parts of it, so that the whole material instantly becomes spongy, and thus capable of receiving and discharging electricity.

Regarding the prior use sworn by Professor Vander Weyde, it must be held that upon his testimony alone the Court would not be justified in overthrowing the patent. The granting of the patent raises a strong presumption of novelty. Clear and convincing proof must be advanced to upset it. Proof which leaves the mind in doubt, or evenly balanced upon the question, is not enough.

The evidence of prior invention of Charles F. Brush is now to be considered. In determining this question, Faure, being at that time a citizen of France, is not permitted to claim the invention earlier than the date of his French patent, which was October 20th, 1880, and possibly not earlier than December 7th, 1880, which is the date of the decree under which it was delivered. Mr. Brush testifies that in the latter part of 1878 he first became familiar with the discoveries of Planté, and learned that the lead plates constructed by him required several months of electrical treatment in order to produce the necessary active coatings on their surfaces. In December, 1878, or very early in 1879, he conceived the idea of making a secondary battery by applying mechanically to suitable plates an active or absorbing coating, so that such plates might be used at once, after suitable charging, without the tedious preliminary forming process described by Planté. For this purpose he took a piece of sheet lead about 3 inches wide and 12 inches long, and sprinkled thereon finely divided metallic lead, in the form of a fine powder. The lead powder was held in place by blotting paper, the edges of which were turned back and under the plate at the sides and bottom. In July, 1880, Brush made lead plates with deep grooves; into the grooves of some he rammed yellow oxide of lead. Early in September, 1880, he prepared six deeply grooved lead plates, and filled the grooves of two of them with litharge, and two more similarly with sulphate of lead. He charged them in a suitable vessel containing dilute sulphuric acid, and in a few days the oxide of lead in the one case and the sulphate of lead in the other was reduced to the metallic state. He suspended the two plates which had been filled with oxide of lead opposite each other in a jar filled with dilute sulphuric acid, and treated similarly the pair having their grooves originally filled with sulphate of lead and the pair whose grooves were not filled at all. He marked these cells 1, 2, and 3 respectively, and connected them in series, charged from a dynamo, and made several tests. After Faure's patent was issued in 1882 interferences were demanded by Brush, and resulted in decisions in his favour at all stages during the progress through the Patent Office.

The evidence of Brush as to what he accomplished in 1879 and 1880 must be accepted as true, and although Faure was *de facto* the first inventor, Brush was *de jure* the first inventor of the electrodes described by him.

It, therefore, becomes apparent that the combination of Faure's first claim, construed as it must be construed under the loose and inaccurate language of the specification, is anticipated in every form in which the active layer can be applied, *save one*—namely, in the form of a paint, paste, or cement. The question now considered is, can the patent be saved to this extent? The application in the form of a paint, paste, or cement was the real invention which Faure made. It was in this form that he gave it practical embodiment; it was this that the scientific world understood to be his improvement.

It is, then, established with reasonable certainty that the discovery of a mechanically applied layer of lead, or like substance, insoluble in the electrolyte and placed upon the supports in the form of paste, paint or cement prior to their immersion in the battery fluid, so as instantly to become capable of receiving and discharging electricity, was one of great merit. Can Faure hold the fruits of his genius, or must the Court decide that in attempting, through mistake or ignorance of what had previously been accomplished, to grasp more than he was fairly entitled to, he has lost what actually belonged to him? Believing that Faure is an inventor of more than usual merit, it can readily be inferred that the Court enters upon this enquiry with every disposition to give him the benefit of his actual invention, if possible to do so under the law. The proof establishes two propositions with equal clearness: First, *Faure was the inventor of a secondary battery electrode coated in the manner stated;* and second, *he was not the inventor of an electrode otherwise coated.*

If, by means of a disclaimer, the patent can be restricted to the actual invention, this course should, in fairness, be adopted.

No one will infringe unless he constructs his battery in the one way to which the patent will be confined. This is the patentee's way, and it has many distinguishing characteristics which differentiate it from the ways pointed out by others. The matter to be relinquished is distinct and separate and can be excised without mutilating what is left. The claim read in the light of the description is too broad. It is sought to limit it. The disclaimer suggested will not make a new patent or a different invention. The invention is fully described in the specification, and the limited claim will stand on that description. The fourth claim, if construed to cover the defendant's structure, is void for want of novelty. It is for a combination of the following elements :—

First. A secondary battery.

Second. A series of cells.

Third. In each cell a pair of electrodes with an active spongy layer thereon.

Fourth. Non-porous partitions between adjacent cells.

It is argued with force and plausibility that it was the intention of the patentee, as shown by these extracts from the specification, to cover only his special construction, the novel feature of which is the non-porous partition with which the electrodes are combined, and to which they are applied. It is asserted that this intention is rendered more certain by an examination of the file wrapper, where it is still more clearly disclosed, and that nowhere in the specification is there a description of the apparatus as constructed by the defendants. In view of these facts, and because the patentee, in effect, disclaimed the construction sought to be placed upon the claim by the complainant, it would seem that the defendant's construction has much in reason and authority to support it, and is the more rational of the two. *So constructed, the defendants do not infringe the claim.*

The patent granted to Joseph Wilson Swan, February 17th, 1885, is for an improvement in secondary batteries. The application was filed January 18th, 1882. The object and aim of the patentee was the production of plates having surfaces more suitable for holding the active material. In carrying this idea out he prepares plates with perforations, cells, or holes extending through the plates in which the active material is packed. The claim is :—"A perforated or cellular plate for secondary batteries, having the perforations or cells extending through the plate and the active material, or material to become active, packed in the said perforations or cells, substantially as described."

The specification states that the patentee has obtained a patent in Great Britain for the same invention, dated May 24th, 1881. It is argued that this allegation carried the invention back to the date of that patent, although the patent itself has not been introduced in evidence. No authority is produced to sustain this contention. Being a mere declaration, unsupported by proof, it is thought that it cannot be accepted as the date of the invention, which, in the absence of proof, must be taken as of the date of application, January 18th, 1882. The experts on both sides agree that an electrode so constructed has marked and peculiar advantages.

It is insisted that the patent as issued is an unlawful expansion of the original application, and, therefore, within the rule of Railway *versus* Sayles. The argument is based upon the assumption that in the original specification the patentee nowhere describes electrodes with perforations extending through the plates, and that it was not until May 24th, 1882, that he mentioned a perforated plate. The complainant denies this, and asserts that figs. 1 and 2 in the patent, as issued, are identical with these figures in the original drawings. Positive proof of this statement has not been found, but the presumption that it correctly states the fact is very strong. The original specification states that :—"The plate shown in figs. 1 and 2 is constructed with cells or cavities for the reception of spongy lead. . . . . The cells may be closed on one side as shown in fig. 3." The only rational construction would seem to be that as the last figure showed the cells closed on one side the two others showed them not closed, but open through the plate.

The question arises whether there is anything in the Act prior to January 18th, 1882, which anticipates the claim or renders it invalid.

The English patent granted to John S. Sellon does not anticipate, for the reason that though dated September 10th, 1881, it was not sealed until March 10th, 1882, after the filing of Swan's application. It was not made public until March 10th, 1882.

But the evidence of Prof. Asahel K. Eaton, if it does not amount to a complete anticipation, so narrows the field of invention that nothing remains of which to predicate patentable novelty. It is thought, however, that as to some of the electrodes made by him there can be no doubt that they fully anticipate Swan's claim. Prof. Eaton testifies that in 1881 he made experiments in secondary batteries, using perforated lead plates for electrodes. These plates were perforated by means of a belt punch. Lead sponge, previously prepared, was then precipitated upon both sides of the plate, so as to cover the surfaces and fill the perforations. He says :—"I afterwards adopted one of the methods which I had tried, when I used two perforated plates with the sponge deposited upon one or both of them and the two plates put together so as to retain the sponge between them, the sponge filling the perforations. This made one electrode. The other electrode was made with two similar perforated plates, the peroxide being made into a paste with sulphuric acid and water, and pasted upon each side of a piece of asbestos. This was put between the two perforated plates and pressed down so that the paste covered the whole surface of each half plate and filled the perforations. Some of these plates were perforated so as to leave a burr projecting in one direction, which aided in the retention of the paste, the two burred surfaces being outside. This provided an enlarged cellular cavity."

In July, 1881, he made another battery with the assistance of G. Farrington, who corroborates him. Perforated plates were used. The paste was urinium mixed with sulphuric acid and water, filling the perforations. Besides Farrington, he is corroborated by Sleeper, who assisted in the construction of the batteries. The Court is not permitted to reject the evidence of unimpeached and respectable witnesses when they are corroborated, and there is nothing to cast a doubt upon the truth of their statements. Upon this evidence, therefore, *the first Swan patent must be declared invalid.*

The second patent granted to Joseph Wilson Swan is dated May 26th, 1885. The application was filed May 3rd, 1883. The claim is as follows :

"In a battery plate or electrode composed of a conducting support in the form of a plate with angular or equivalent holes, cells or perforations extending through the same, and separated from one another by webs, walls, or partitions of uniform cross-section, the active material being placed in said holes, cells, or perforations, substantially as set forth."

This would seem to be for the same subject matter covered in the first patent of Swan. It is conceded that the alleged invention is described and shown in the first patent. The only difference suggested is that the second patent is for a more limited subdivision of the same general invention. The specification states : "It should be observed that I do not claim herein, broadly, the use of plates provided with holes or perforations extending through the same, and having the active material, or material to become active, held in such holes or perforations, as this forms the subject matter of patent granted to me on the 17th day of February, 1885."

It will be observed, said the Judge, that the drawing of the first patent shows a plate made in exact accordance with the "limitation that the webs, walls, or partitions between the cells shall be of substantially uniform cross section," and that the specification states that the form of the cells may be greatly varied without departing from the principle of the invention. Even

if the second patent can be distinguished from the first in the particular stated by the experts, it is quite clear that the difference pointed out is wholly insufficient to sustain invention. After the first patent there was absolutely no room for a second patent; which upon the most favourable construction for the complainant, simply claims an arrangement which anyone who had sense enough to make the perforations at all would most certainly adopt. When a patent has been granted for a plate containing rows of holes, another patent cannot be granted for the same plate containing *uniform* rows of holes; neither can there be anything patentable in the mere shape of holes.

Swan describes no invention in the first patent which is not covered by the claim of that patent. What is not claimed is not patentable.

It follows, therefore, that the complainant, upon filing a disclaimer, limiting the first claim of the Faure patent to an electrode of a secondary battery, to which the active layer is applied in the form of a paint, paste or cement, insoluble in the electrolytic liquid, is entitled to a decree for an injunction, and on accounting upon the claim as thus limited, but without costs."

RECENT ADDITIONS TO THE SPRAGUE ELECTRIC ROADS.

THERE is nothing so indicative of the success which has attended the electric street railway installations in America than the repeated increase of apparatus ordered by street railway companies using the electric system. Quite recently a large number of street railways operated upon the Sprague electric railway system have ordered an additional number of cars in view of the increased traffic during the summer months which is expected by many of them.

Among the railways which have requested additional equipments are those at St. Joseph, Harrisburg and Wilmington. These railroads have already ordered one set of additional cars, and this order makes the third received by the Sprague Company, in each of these cases, for more cars. The representatives of all these companies have written to the Sprague Company expressing satisfaction with the operation of their roads. The East Reading and Black Bear Railroad, which has been operating for only two and a half months, has proved to be so great a success that the directors of the road have desired an additional number of cars.

In St. Joseph, Mo., where there are two electric railways on the Sprague system, the Union Passenger Electric Railway and the Wyatt Park Electric Railway, both of these companies have ordered an additional number of cars to accommodate the somewhat anticipated traffic. The additional equipments of the Wyatt Park line calls for four new Sprague cars, and the additional equipment ordered by the Union Passenger Railway also includes four cars with dynamo and station appliances. The factory of the Sprague Electric Railway and Motor Company is now working to its fullest capacity to supply these large orders and to fill the new contracts which have been sent in during last month.

ELECTRIC LIGHT PROVISIONAL ORDERS.

BOARD OF TRADE INQUIRY.

(*Continued from page* 392.)

THIS investigation was resumed by Major Marindin, R.E., on Thursday week at the Westminster Town Hall. The Inspector is assisted by Captain Cardew, and the following counsel and other gentlemen appear for the several companies and local authorities interested: London Electric Supply Company, Mr. Pember, Q.C., Mr. A. K. Lloyd, and Mr. J. C. Graham; Metropolitan Electric Supply Company, Mr. C. A. Cripps; Electrical Power Storage Company, Mr. Moulton, Q.C., and Dr. Hunter, M.P.; Chelsea Electricity Supply Company, Mr. Moulton, Q.C., and R. S. Wright; Strand District Board of Works, Mr. Cripps and Mr. F. M. Jenkins; Greenwich District Board of Works, Mr. James Spencer; Paddington Vestry, Mr. J. H. Horton; St. Olave's Parish, Mr. Bailey (clerk to the Vestry), and Mr. Thompson (surveyor); Great Eastern Railway Company, Mr. E. Moore, solicitor; St. James's Electric Supply Company, Mr. Muirhead; St. George's (Hanover Square) Vestry, Mr. Hitchins; Notting Hill Company, Mr. Roger W. Wallace; City of London, Mr. Russell Griffiths; Marylebone Vestry, Mr. Cripps and Mr. Greenwell; Lambeth Vestry, Mr. H. J. Smith and others; Westminster Supply Company, Mr. Roger Wallace, London County Council, Mr. J. Percy Gunyon, engineer, and two members of the Council; St. James's (Westminster) Vestry, Mr. Wilkins (clerk), and Mr. W. Jenkins, chairman of the lighting committee; Holborn District Board, Mr. Hopwood, solicitor; St. Martin's-in-the-Fields, Mr. Webster Murnane (clerk); St. Pancras Vestry, Mr. T. E. Gibb (clerk), and Prof. Robinson, C.E; Kensington and Knightsbridge Company, Mr. Roger Wallace; North London Railway Company, Messrs. Payne, Son, and Pollock; Bermondsey Vestry, Mr. Harrison, solicitor.

The EARL OF CRAWFORD AND BALCARRES was again cross-examined.

In reply to Mr. G. GOLDNEY, on behalf of the Commissioners of Sewers, he said he objected to exclude the City of London from the order of the London Electric Supply Corporation, because it practically formed a part of their way up, and also because there was a great deal of lighting to be done in the City in the daytime, and that was an important consideration. They proposed to enter the City at Cannon Street and at Ludgate Hill, and they hoped eventually to enter further east. He could not off-hand allocate the capital for lighting the City, but he could give an estimate if he were told how many lights were required. They were prepared to supply as many lights as were asked for, and they did not wish to take a way-leave through the City without accepting all the proper responsibilities. They would light the City according to what the City was prepared to pay for, whether by the arc or incandescent method. In the requisition recently issued by the Commissioners of Sewers, there were three districts in which 388, 526 and 633 gas burners would be required, but 500 arc lights would suffice for those districts instead of the 1,547 gas burners. The Supply Corporation was prepared to provide the light to the City on as good terms as they offered to any other customers. He had not thought it necessary to waste time in working out a hypothetical scheme for the City which the Provisional Order might at once upset. The City of London was in the schedules to the Acts, and therefore the company proceeded under those Acts. He was aware that there had been experimental electric lighting in the City, but he was not aware that the Commissioners of Sewers had done it.

Replying to Mr. C. A. CRIPPS (for the Metropolitan Electric Supply Company), Lord Crawford stated that it was his conviction that it was more economical to buy light from one large station than from several small stations, and that system was more convenient in regard to coal. He was not aware that with modern appliances a cheaper coal than "navigation coal" could be used without detriment or nuisance, and they had failed to do so at the Grosvenor Gallery, owing to the noise which modern appliances made. He was not aware of what the arrangements were at the Whitehall generating station, because he had never had the privilege of looking into it; but he did not think his company could work in the same manner, because of the neighbours in a crowded district. At Whitehall there were not neighbours of the company except the Hotel Metropole, and that could not complain of noise because it was also working an electric light system.

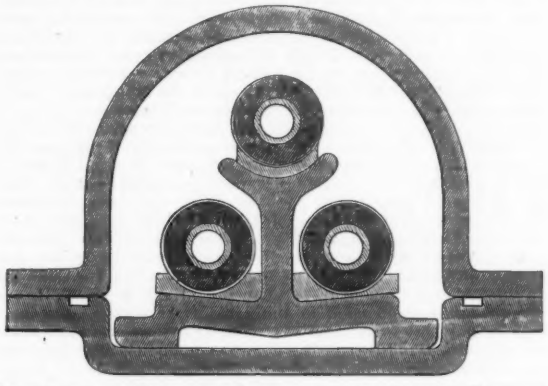
By Mr. SHIRESS WILL, M.P. (House to House Supply Company.) The company had unit machines in the same way as the House to House Company had, but larger. If they had supplied one mile they could then go on commercially and gradually advance as the demand increased creeping from a number of centres. To do one mile from each of their proposed 18 centres would cost from £25,000 to £30,000, 12s. 6d. a mile being for excavation.

After cross examination by Mr. MUIRHEAD for the St. James's Supply Company, and one or two other representatives,

LORD CRAWFORD was re-examined by Mr. LLOYD, to whom he stated that the corporation of which he was chairman had ample capital to provide and allocate 10,000 lights to Deptford and Greenwich, 10,000 to Rotherhithe, 10,000 to Bermondsey, 10,000 to St. Olave's, 10,000 to St. Saviour's, 10,000 to Lambeth, 20,000 to St. Martin's in the Fields, 15,000 to St. Margaret's (Westminster), 30,000 to St. George's, Hanover Square; 15,000 to Chelsea; 15,000 to St. James's; 15,000 to the Strand; 10,000 to St. Giles'; 15,000 to Holborn: 10,000 to Clerkenwell; 30,000 to the City of London; 15,000 to Marylebone, and 15,000 to St. Pancras. They were also prepared to supply the City with 100,000 lights in the day time. As to overhead wires, he objected to the local authority having power to order the wires down before the underground work was completed. He would engage to take them down as rapidly as possible when the underground work was done.

Mr. SEBASTIAN ZIANI DE FERRANTI, electrican to the London Supply Corporation stated in examination by Mr. GRAHAM that the excavations at Deptford covered about 200 feet square, and the company had put down buildings and chimneys for 40,000 horse-power. Of that there was now under steam 6,000 horse-power. The remainder of the plant was being put down. There were two sets of engines each capable of generating for 25,000 lamps. The horse-power at present arranged for would supply 250,000 lights, and they had contracted for further machinery would which increase that number to 450,000 lights. He saw nothing extraordinary in

the 5,000 horse-power engines they were having, and now that he saw how steamships had gone ahead, he was sorry the company had not got a larger engine. Of the 250,000 lights he had mentioned, it was proposed to work up to only 150,000, leaving a margin to facilitate repairs, and to provide against failure of supply through accident. They were laying down six mains, two of which would be brought to Cannon Street, two to Blackfriars Bridge, and two to Charing Cross. They were concentric conductors, and were laid from Deptford to London Bridge, and then separated in the manner described. They were carried on cast iron brackets on the railway, and would be thoroughly insulated. Each main would carry a supply for 10,000 10-C.P. lights, and they were so designed that any one of them could be thrown into connection with any of the engines at Deptford in the event of the breakdown of an engine. The tension in the mains was 10,000 volts, but by the converters that would be reduced to 2,400 volts. The transformers in each distributing station were divided by the two mains, each of which thus had two different kinds of current, part from one dynamo, and part from another. The supply was therefore duplicated, and if one main failed the other would have ample capacity to supply the whole demand. At the distributing stations the converters would be worked approximately up to their normal power, but they found by experience that for a short time they could work them up to twice their normal power. If one failed it would be cut out by its own fuse automatically. These converters lowered the potentials to practically one-fourth of what was started with. Each distributing station would practically be a small Grosvenor Gallery, with the advantage of a very perfect duplicated supply. The transformer was simply a reducing valve with very little loss; it served the same purpose as a regulator, reducing the pressure of gas or steam or water, but the difference



SKETCH OF THE ORDINARY CONDUIT OF THE LONDON ELECTRIC SUPPLY CORPORATION.

was that the loss was very slight in regard to electricity. The loss in the Deptford mains would be about one-fifth per cent. of the energy per mile run; so that if there were five miles of trunk, there would be a loss of one per cent. If there were short circuiting or imperfect insulation between the outer and inner copper, the only evil would be that the conductor would not be of use for conveying the current, but the external effect would be practically nothing. It would not hurt any one to touch them when at full work. The insulating capacity of these mains had been tested very severely. He had tested them repeatedly up to one million volts without getting through or injuring the insulation; with the pressure they were working at that would give them a safety margin of 100 to 1, which was enormous in a case like this. This system was, in his opinion, perfectly safe in every respect—safe externally from the station, and as safe internally as moving machinery could be. The pressure at which they worked had not an element of danger. There was great economy in doing a large business of any kind, and if this were carried on all under one roof the expenses must be low. The first great advantage of this system was having the generating stations outside the area of supply; then came the important consideration that there was no noise, no steam, no smoke, and no nuisance; and then there was the avoidance of a failure in the supply of coal through a snowstorm or other impediment to traffic. At Deptford they had a considerable storage space for coal. Above the boilers alone there was storage for 4,000 tons, which dropped by its own weight on to the fire; and besides that from 30,000 to 40,000 tons could be stored in the yards. Through being on the banks of the Thames they would get water cheaply. In the distributing stations the floor space required for the transformers would be about 2 feet by 3 feet per 1,000 lights, and a small wall space for the switches. In further evidence Mr. Ferranti said he had not been to America, but he was constantly advised by an engineer of what was done there, and he learned that electric lighting there on the transformer system was carried on now to an enormous extent. In Paris, the Municipal authorities had adopted it as a model to the people to guide them in investing in the light, and at Nancy there were at present 10,000 lights running on the same plan; at Milan, at Rome, and other places on the Continent it was largely in use.

Cross-examined by Mr. MOULTON, Q.C., the witness said he estimated that for 100,000 lights not less than 200 tons of coal per day would be required. He had not run a storage system, and was not prepared to mention an estimate of coal under that system. At the Grosvenor Gallery they had had a great deal of trouble about injunctions, but he had never himself said the complaints were unfounded. The company had done a great deal to prevent vibration, but they had not succeeded entirely. Dynamos such as they were having were not new experiments, inasmuch as the design of the dynamo made it a combination of a number of small machines; but there had not before been so large a dynamo built. They were to work up to 10,000 H.P., which was about 20 times the power of the dynamo at the Grosvenor Gallery. A dynamo of 10,000 H.P. would do something like as much work as all the 120 or 130 installations in America of which he had heard. He expected to supply about 200,000 10-C.P. lamps, but no dynamo hitherto had supplied more than 800. The design was simply a combination of one wheel upon several wheels. The pressure of 10,000 volts was four times the ordinary pressure in London, and three times the pressure in the alternating system. The mains were to be put underground, and they already had many miles of mains, with a pressure of 2,400 volts, running underground from the Grosvenor Gallery; and at Nancy they were running 10,000 lights with 2,400 volts. They had had converters which leaked at the Grosvenor Gallery, but an apparatus had been invented which remedied that. He did not recognise that as a difficulty, though some people did. The apparatus had been fully tried and so worked as to cut off the current at the consumers' very door. There was no difficulty about insulation with underground wires. Those from the Grosvenor Gallery were for the most part not tapped for private houses. Up to the present time there was no alternating current motor in commercial use in this country, but he had heard of a number of small ones being used in America. The Westinghouse Company were using one he was informed. As to motive power he agreed with Lord Crawford, that it would become very important, and in some districts be largely in demand.

On the renewal of the enquiry on Friday, Mr. FERRANTI was further cross-examined by Mr. Moulton, Mr. Shiress Will, M.P., Mr. Roger Wallace, Mr. Russell Griffiths, and other representatives.

Mr. STRACHAN, surveyor to the Chelsea Vestry having spoken in favour of the order applied for,

Dr. J. AMBROSE FLEMING, professor of electrical engineering at University College, London, was examined by Mr. GRAHAM. He stated that he had visited America in 1884 and 1885, and carefully examined the electric light systems there in operation, especially the Edison system. The transformer system had not then come to the front much, but since that time it had enormously extended, and there were now more than 200 central stations. They were worked similarly to the system of the London Supply Corporation, and he had not heard that there had been any difficulties as to insulation. The system had also been largely adopted in Europe. In America the reserve power was embodied in spare engines, boilers and dynamos. A tension of between 1,000 and 2,000 volts was a usual tension in America. With regard to insulation, the higher the degree of electromotive force, generally speaking, the greater were the precautions that would be required, but there was no impossibility about it. In New York there were about 100,000 lights per square mile in an ordinary business district. The witness expressed concurrence with Mr. Ferranti's view as to leakage and efficiency of the transformers, and did not regard this system as experimental, otherwise than as being something larger than had been done before.

Mr. MUSGRAVE HEAPHY, C.E., adviser to the Phœnix Insurance Company, explained the rules which this company had drawn up with a view to safety in the use of electric lighting, and expressed the opinion, having examined this system very largely in London, that it could be used without danger, especially if those rules were observed.

Major WALLER, manager and secretary of the London Electric Supply Corporation, gave evidence respecting the applications received by the Corporation for a supply of light, and the agreements already made; and the Court again adjourned.

On Saturday morning Mr. C. A. CRIPPS proceeded to state the case of the Metropolitan Electric Supply Company, and remarked at the outset that there appeared to be two main points which could be easily established to the satisfaction of the Board of Trade. The first point was that the company was in a thoroughly sound financial position; that it was supported by men of great eminence in financial circles; that it had ample capital for all it proposed to undertake; and that, if additional capital was necessary, there would be no difficulty in finding it. The other point was that the system proposed to be adopted was the best and safest; that from an economical point of view it would stand comparison with any other system; and that, with regard to safety and convenience to the consumers, it stood in the best position of all. The capital of the Metropolitan Electric Light Company was £500,000, in £10 shares, and when the prospectus was issued the amount was subscribed twice over; £3 per share had been paid up, and the number of shareholders was no fewer than 700. Already the company had entered into obligations to spend a sum of £380,000, and the districts which they proposed to include for purposes of electric lighting were comprised in the first instance in four Provisional Orders As regarded one of these, however, the North London, the directors of the company, after careful consideration, had decided not to ask at that enquiry for any compulsory powers at all, and, in fact, withdrew their application in respect to that order. The first order upon which he should ask the decision of the Board of Trade was the Mid-London order, which included the parishes and districts of the

City of London and its Liberties; St. John the Evangelist, Westminster; St. Margaret, Westminster; St. George, Hanover Square; St. Giles-in-the-Field; St. George, Bloomsbury; St. Andrew, Holborn-above-Bars; St. George-the-Martyr, St. Sepulchre, Saffron Hill, Hatton Garden, Ely Rents, and Ely Place; the Liberty of Glasshouse Street; St. Anne, Soho; St. Paul, Covent Garden; St. John-the-Baptist; the Savoy, or the Precinct of the Savoy, St. Mary-le-Strand; St. Clement Danes, the Liberty of the Rolls, the Charterhouse, Gray's Inn, Lincoln's Inn, Staple Inn, Furnival's Inn, and the Close of the Collegiate Church of St. Peter. The next order was the South London order, comprising districts of Lambeth, and the last order, the West London order, included the parishes of St. Marylebone and Paddington, while the parish of Kensington was excluded. The company already had a station at Whitehall with a capacity of 12,000 lights, and arrangements had been made for a station at Sardinia Street with a capacity of 50,000 lights, another at Rathbone Place for 24,000 lights, another at Manchester Square for 50,000 lights, another at Eccleston Place for 40,000 lights, and finally another at Waterloo Bridge for 20,000 lights. In the City arrangements had been made for a station where 120,000 lights would be provided.

Major MARINDIN asked whether there would be any difference between the distributing and the trunk main.

Mr. CRIPPS said all the mains would be distributing mains. The distributing and generating mains would be the same, so that the great main or mains would more properly come under the definition of distributing mains than under that of trunk mains. The proposal was that these generating stations should be from one to two miles apart, and of sufficient size to fully utilise the staff employed in view of an economy of labour. The mains would be copper wires insulated with vulcanised India-rubber and covered with tape soaked in a preservative preparation. These would be drawn into cast iron gas pipes, and there would be test boxes, and, in regard to private supplies, junction boxes.

Sir JOHN PENDER was then called. In reply to Mr. LITTLETON, he said he was the chairman of the Eastern Telegraph Company, a director of several public companies, and of the Metropolitan Electric Supply Company. He bore out the opening statements of Mr. Cripps, and said that the £351,000 already expended left an ample margin for moderate extensions. He did not believe for a moment that there would be any difficulty in raising additional capital if it was necessary. Electricity now was just in that position that any day wonderful developments might be witnessed, and for that reason the company had been proceeding on the safe principle of developing gradually and of taking up any new development which might arise. The present system was one of separate installations, but the company were not bound to any particular system. In laying down the mains the company would always have regard to the question of the supply of power. Improved systems would be adopted as they were invented, and if the systems now adopted were as successful here as they had been in America and other places where they had been established, the success would be such as to leave no doubt of their getting any amount of money to carry on the lighting of London wherever that light might be required.

Mr. JOHN EDWARD HENRY GORDON, electrical engineer to the company, was examined by Mr. CRIPPS: He had, he stated, had charge of the designing and constructing of the company's several stations. The Whitehall station was intended for a compact district, where there was no necessity for special arrangements for distribution. The system there was worked by direct current and storage batteries, with a pressure in the engine room of 110 to 116 volts, and 100 volts over the whole district. There had been no difficulty with respect to vibration or smoke. The other stations were worked on a different system, suitable for districts where the consumers might not be next door to each other. For this purpose they had the transformer system, with an alternating current and a pressure of 1,000 volts in the mains, but only from 50 to 100 volts for the customers. The Sardinia Street station was being constructed by the Westinghouse Company, because they had erected 120 or 130 such installations in the United States, and the Supply Company were anxious to have the full benefit of their experience. That station was nearly completed, and provision would be made in the first instance for 24,000 lights. At Rathbone Place 2,000 lights would be provided for at the outset, but with machinery to work up to 24,000 lights. They proposed to use Elwell-Parker dynamos, and to drive them with Willans direct driving engines, such as they had at Whitehall. They would leave a large margin in engine power. At other stations the same machinery would be used, but at Waterloo Wharf the plant would consist of Kapp dynamos driven by Hornsby engines. In none of these cases would there be any nuisance from smoke or vibration. The company had spent about £370,000—£195,000 on machinery, £50,000 on buildings, £80,000 to £100,000 on mains, and the remainder on leases and sites. The centres as at present arranged would not supply the whole districts for which power was asked, but there would be no difficulty in increasing them. The centres were so arranged as to overlap each other to provide against a breakdown in any of them. The highest pressure that as far as he knew had been used for electric light was 2,500 volts under the alternating system which they intended to use; and with that tension there would be no difficulty respecting insulation. That would be secured by the employment of the best vulcanised rubber, covered with protective tapes. The mains would be placed underground in ordinary 3 to 5 inch gas-piping; and at short intervals they would place junction boxes, which also would be covered. Those would enable the workmen to insert or withdraw wires without much trouble or public inconvenience. Then at every 200 yards there would be a testing box just large enough to admit a workman. Referring to the question of nuisance the witness said he erected the installation at Paddington Station. At first there was some annoyance, chiefly from clouds of dirty steam which formed a fog over the neighbourhood. They had, however, remedied that, and he had not heard of any complaints for two years.

In cross-examination by Mr. PEMBER, Mr. GORDON said he calculated that for 20,000 to 30,000 lights the consumption of coal did not exceed 100 tons a week in the winter, or 60 tons a week in the summer. When all these stations were working the consumption would amount to about 30,000 tons a year—for 200,000 lights. The company had storage at every station for a week's supply, and further accommodation at Waterloo Wharf and at Greenmore Wharf. The coal would of course have to be carted through the streets from one or other of these wharves. With regard to vibration, he had taken people to stand over the engines at Whitehall within a few feet of them, and they could not tell where the engine-room was. There the company condensed the steam to sell for warming purposes, and it was worth £1,000 a year to them. He did not anticipate any difficulty in making arrangements with the London Company for laying mains jointly.

In reply to Mr. RUSSELL GRIFFITHS, witness said he thought they would be able to find room in the City for laying the mains. They were in various lengths, up to 18 feet, and they would be placed about 12 inches below the pavement, and somewhat deeper under the roadway. There would be no overhead wires.

Dr. JOHN HOPKINSON, F.R.S., examined by Mr. LITTLETON, described this system as a combination of a large number of moderate sized machines, which were a great advantage for meeting a varying demand. Under this system the supply could not totally fail, for if an accident occurred in one district the supply could be obtained from another through the overlapping plan. The limit of 1,000 volts of pressure was the result of considerable experience, which showed that although there were some advantages in a higher potential they would be counteracted by a possible breakdown of the potential, either in the transformers or the mains. Only one transformer would be used between a consumer and the source; for every additional transformer meant a small additional loss of power. The advantage of direct supply over a supply with accumulators turned largely upon the cost of the latter, which probably amounted to £30 per horse-power; while there was a loss of, perhaps, 30 per cent. in energy. For occasional purposes accumulators were useful, but not for a general demand. He did not anticipate any difficulties that could not be overcome.

In answer to Mr. LLOYD, Dr. HOPKINSON, referring to Mr. Ferranti's tension tests, said it had long been known that if there was an insulation of three-quarters of an inch, would it stand, if good, a very high tension; and in reply to Mr. ROGER WALLACE he said he had had experience of accumulators at work in Vienna, but he did not know what the loss was under that system; and for this company's purposes accumulators would be of no use. Witness was also cross-examined by Mr. Moulton and by Mr. Griffiths, and Dr. Fleming having been recalled and cross-examined by Mr. Moulton,

Mr. WALTON, manager of the Paddington installation, gave evidence confirming previous statements as to the stoppage of all nuisance at those works.

Mr. THOMAS SPENCER, electrical engineer to the Westinghouse Company, stated that he had erected a number of the central stations in America. These were on the transformer system, with a pressure of 1,000 volts as a rule. A somewhat higher tension had been tried, but the 1,000 volts limit was found to be the best and was universally adopted.

Professor GEORGE FORBES, examined by Mr. CRIPPS expressed the conviction that the system proposed by this company was in every way the best that in view of present knowledge could be adopted. A constant pressure could be maintained better under this method than under any other. The system was also an economical one, and it possessed many other advantages; of which the overlapping of districts was a most important consideration. He had studied electric lighting in America and had come to the conclusion that this system was and must be thoroughly satisfactory in operation. The battery system was scarcely used in America. He had formed the same opinion upon the working of the system in Milan, Rome and other cities where he had investigated the system.

The enquiry was again adjourned, and on its resumption on Monday morning Professor FORBES gave, in cross-examination by Mr. MOULTON, Q.C. (for the Electrical Power Storage Company), Mr. Russell Griffiths, and others, further evidence on questions of experience. Reference was made to the installation of electric lighting in Rome and other places abroad. The largest engine at Rome was 400 horse-power, and at Berlin 600 horse-power. The cost at Rome for electricity, from various causes, was higher than what it was proposed to be in London. The system of the Metropolitan Company was with transformers, with 1,000 volts pressure in the distributing mains, and, as a general rule, each distributing main was connected with one generating station while in action. He stated that he had made a report as to the lighting of Paddington, and he put in a copy of the detailed report he had made.

Mr. SIEMENS, Vice-President of the Institute of Electrical Engineers, examined by Mr. CRIPPS, stated that he had had great experience in respect to electric installations at home and abroad, but some of the latter were not put up under his personal superintendence. At Berlin the system at work was one of central stations for supply. He gave descriptions of the systems at

Moscow and St. Petersburg, and he had been taken over the systems at work in different German towns. Asked as to the best system, in his opinion, for London, he said that he considered the transformer system would be the best, with a number of supply stations. The largest pressure of current he had known was 5,000 volts; but 10,000 volts current had been raised at the works at Woolwich. There would be no danger in running 1,000 volts, nor leakage if the mains and joints were properly made. After questions by Mr. Moulton, Q.C., on technical points, the witness said, in reply to Mr. Shiress Will, Q.C. as to the alleged nuisance of electric stations from noise, vibration, and smoke, that he did not know of such complaints in Berlin, and at the Savoy Theatre in London an installation had been run without any complaints; and, in fact, people did not know the station. In answer to other questions, the witness said that in Berlin there was private lighting as well as public lighting from the same system. The 10,000 volts of which he had spoken as carried out at Woolwich was an experimental current, and it went through only a short cable. In the City of London, for one year, his works had lighted London Bridge, King William Street, and Poultry, and he had offered to go on longer.

Sir WILLIAM THOMSON, F.R.S., examined by Mr. CRIPPS, said he was acquainted with the system of electric supply by alternate currents and with tranformers, and he regarded this system as the best for London. As to the highest pressure he knew at work, he said at the Grosvenor Gallery it was as high as 2,400, and was safely worked by the transformer system.

Questioned by Mr. J. C. GRAHAM, Sir WILLIAM THOMSON said that he saw the works of the London Electric Supply Corporation at Deptford when they commenced. He was aware of the high tension proposed by the London Electric Supply Corporation, and asked if he knew of any practical difficulty in going up to 10,000 volts current, as proposed by that corporation, he said he knew of no insuperable difficulty in raising that voltage. It had, hitherto, however, only been within the laboratories of electricians as experiments that this voltage had been raised. He could not say that there was any insuperable difficulty in the way of properly insulating the mains, as proposed by the London Electric Supply Corporation, though he regarded it as a large experiment, but he had no doubt any difficulty would be overcome. He did not anticipate any difficulty from insufficient insulation nor any danger to life from the high potential proposed—there was no more danger, under proper care, from a high potential than from the working of a circular saw.

In answer to other questions as to the reserves of power, Sir William said that reserve batteries would be sufficient for small domestic supplies; but that duplicate engines would be necessary for large supplies. The direct system had many years' start of the alternate system; but the latter had now made a very great advance. He would not say that the number of lights by the alternate system exceeded the lights by the direct; but he knew that the former supplied very many lights both in America and London. He also said that there would be no difficulty in reducing a tension from 10,000 volts, when once such a system was installed; but there would have to be a change of dynamos and coils to effect this lessening of tension.

Questioned by Mr. MOULTON, Q.C., the witness said that a number of generating points in a supply, though not necessary, would be advantageous. He had not come to a conclusion as to whether the direct or the alternate would be the better for all time for London; but he did not think that the alternate was only applicable to sparse localities, as suggested by the questioner.

In answer to Mr. SHIRESS WILL, Q.C., the witness said that thoroughly insulating the outside of the mains would be costly, and he could not answer offhand whether, in properly laid lines, a current for 5,000,000 lights could be sent five miles with only the loss in leakage of 1 per cent., as claimed by the London Electric Supply Corporation. Asked if he knew any system whereby one plant was kept idle in reserve while the other was at work, he said that this was the system of the Grosvenor Gallery.

In reply to questions by Mr. WALLACE, he said that the advantage of the transformer system over the direct was that in the latter there was a loss of energy in transmitting over a long distance. When he gave his opinion that engine reserve power was better than storage batteries, he was assuming that the storage was less than a day's supply. He regarded as a remote contingency the explosion of a station boiler. This should not be a question of doubt; it was a matter of care.

In reply to some further questions by Mr. J. C. GRAHAM, the witness said that when he spoke at the York meeting of the British Association of the value of the accumulator system, the transformer was not before his mind. His opinion since was not to say changed in favour of the transformer system. It had, so to speak, grown up in favour of this system.

Subsequently Sir WILLIAM returned and asked to supplement his evidence in regard to details in making installations. He stated that it would be advisable to adopt certain methods in high voltage mains, as the static potential might wander up to a high pitch and so cause inconvenience, not to say danger, under certain circumstances.

Mr. LLOYD, for the London Electric Supply Corporation, stated that the company had arranged to carry out the methods which Sir William Thomson had thus suggested.

Mr. J. S. BALFOUR, M.P., chairman of the Debenture Corporation, and director of the Metropolitan Electric Supply Company, stated that the company had £500,000 capital, which was sufficient for the company's present purposes, and when the company was formed it was contemplated to extend the company's operations in the future. The capital was invited on that basis, and only sufficient was taken for a complete experiment. The expectations first formed had been largely exceeded by the demands for the light. There would be no difficulty in obtaining the capital for the extension.

In reply to Mr. MOULTON, Q.C., who read some of the statements in the original prospectus of the company, the witness justified the statements; and with regard to an allegation in the prospectus that the company last year had a provisional order for lighting certain parts, the witness said this was obtained, but Parliamentary sanction was not obtained for that. Satisfactory negotiations had been made with many parishes in the west and south of London, and the company was already at work in places.

Mr. E. S. CLAREMONT, the manager of the Metropolitan Electric Supply Company, examined by Mr. CRIPPS, stated that their works as laid down were free from objection in regard to noise, vibration, and smoke. They had stations in Sardinia Street (Lincoln's Inn), Whitehall, Rathbone Place, Manchester Square, and Eccleston Place, Belgravia. The cost of laying their mains was from £1,250 to £1,350 a mile. He stated that the company had negotiated with several London local authorities; with some they were successful, some requiring modifications in the proposals, and the Strand district was under agreement, the terms of which would be laid before the Board of Trade. The local authorities were chiefly from central London and from the west and south-west, and the objections of most of these local authorities to the company receiving the order had been met. The Bill the company sought would be brought into conformity with the provisional order sought to be obtained. The company had received applications to supply lights in all amounting to 44,660, in Marylebone, St. James's, St. George's (Hanover Square), the City, St. Martin's, and the Strand. The company was supplying 11,340 lights now. There would be difficulty, he thought, in a clause being inserted in Bills for the companies to arrange about opening the streets at the same time.

In reply to Mr. LLOYD, the witness agreed that it would be unnecessary for a solvent company to make a deposit in the hands of the Board of Trade, and that it should be sufficient for the Board of Trade to be assured of the solvency of a company. As to the suggestion of a nuisance by the station at Eccleston Place, the witness said that there could be no extra nuisance from vibration or noise where the Metropolitan Railway was, for that company had a station near Eccleston Place, and the chimney the Metropolitan Electric Light Company would use had been in use for 16 years. The company had bought this chimney. He had not opposed a second company coming into the Strand or any district.

On Mr. MOULTON, Q.C., raising the question of the company in regard to its provisional order of last year, Major MARINDIN explained that the provisional order was obtained last year, but Parliamentary sanction to it was not obtained, the Bill being opposed.

In reply to Mr. SHIRESS WILL, Q.C., witness said that he would prefer districting to competition in the company's interest; but this would not be in the consumer's interest, who could not change his supply if it should be unsatisfactory in regard to light or price. He saw no objection to competition.

In reply to Mr. WALLACE, the witness said that no negotiations had been made with the House-to-House Electric Light Company. In reply to other questions the witness said that the Duke of Westminster's agent had been informed of the purchase of the Eccleston Place site for a working station. The mains would be laid underground, as a rule, but in narrow places in the City overhead wires would be necessary. He did not think it would be fair to put a clause in a Bill to prevent competing electric light companies from amalgamating without the consent of the local authority.

The enquiry was adjourned to Wednesday to enable Major Marindin on Tuesday to visit the works of the several electric supply companies concerned in the investigation.

(To be continued.)

NOTES.

Easter Holidays.—Correspondents and advertisers please to bear in mind that we publish on Thursday next week, one day earlier than usual.

Exeter Electric Light Company.—We hear that this company will probably be prepared to supply the electric light to shops, warehouses, and private houses by June next.

Theatre Lighting.—Arrangements have been entered into with Messrs. Blakey, Emmott & Co. to light the auditorium of the Halifax theatre with the electric light.

A Resurrection.—We notice on page 425 the name of R. M. Marchant in connection with an engine company recently registered. Is this the R. M. Marchant who acquired such notoriety over engine tests a couple of years ago?

Ship Lighting.—The Fairfield Shipbuilding and Engineering Company launched on Saturday the steel paddle steamer *Calais-Douvres*, built to the order of the London, Chatham and Dover Railway Company for their English Channel service. The *Calais-Douvres* is fitted with all the latest improvements including a complete installation of electric light, with embarkation lamps, &c.

The Chelsea Supply Company.—A telegram from the Secretary of the Chelsea Electricity Supply Company, just as we went to press last night, informed us that the company will supply current in the district continuously from that evening.

Secondary Battery Patents.—The shareholders in the Electrical Power Storage Company will find it interesting to compare the report of the meeting with the judgment delivered in America on secondary battery patents. Both can be read in our present issue.

The Sprague Patents.—We are notified that an English company has been formed to work the Sprague electric traction patents in Great Britain and Ireland.

Telephone Directory.—The National Telephone Company, Limited, has sent us a copy of its present year's list of subscribers, which is just being issued. The company serves a very large number of subscribers in its own English territory, and also that of the Lancashire and Cheshire Telephonic Exchange Company. The whole are given in one book, owing to the extensive system of inter-town communication which exists, and which is rapidly extending in these districts.

Heavy Steel Casting.—A 75-tons ingot was successfully cast at the Parkhead Forge on Saturday. It is the first of a set of crank shafts for the London Electric Supply Corporation, Limited, and is 20 feet long. The shaft into which it is to be forged is 26 feet long by 36 inches diameter, being for the largest electric lighting machine in the world. This shaft, with a 12-inch diameter hole through centre, will itself weigh 23 tons when completed.

The Government and the Cables.—The Secretary of the Eastern Telegraph Company, Limited, writes:—"As a certain amount of doubt appears to exist as to the cables which have been taken over by the Government from the 1st inst., I take this opportunity of pointing out that the lines which are now being worked by the Government are the cables which connect Great Britain with France, Belgium, Holland, and Germany."

New Engines for Madrid Theatres.—We learn that Messrs. Ruston, Proctor & Co., Lincoln, have secured orders for new engines to be employed in the electric light installations in Madrid theatres.

The Electric Light in Chicago.—During the past year the number of electric lights in Chicago has been almost doubled, and now reaches the figure of 43,136 as against 22,756 on January 12th, 1888. The increase is made up of 2,663 arc and 17,717 incandescent lamps. The principal central stations belong to three companies, viz.: The Chicago Arc Light Company, the Merchants' Company, and the Edison Company. The first named commenced operations in 1887 with 830 arc lamps and has now 1,560. The Edison Company was inaugurated last year with 9,000 incandescent lamps, which have since been increased to 12,000. The Merchants' Company runs about 1,000 lights.

Electric Car Accident.—On the 27th March one of the electric cars in descending the Eighth Street hill, Richmond, V.A., jumped the track and dashed down the street to Main Street, where it landed against a tree. The conductor of the car, seeing his danger, jumped out of the car. He fell upon the ground and sustained painful injuries about the head.

Liverpool and the Electric Light.—A special meeting of the Council will be held on the 1st of May to consider the question of consenting to the Liverpool Electric Supply Company, Limited, making an application to the Board of Trade for a provisional order to supply electricity within certain defined districts of the city.

Lighting Montrose Asylum.—The managers have in contemplation the introduction of the electric light into the new hospital, as well as the main building.

Electric Traction in Australia.—A committee of Adelaide commercial men has been interesting itself in the question of electric traction, and a company is to be formed with the view of replacing horses by electricity, it being expected that the cost per car mile will thus be reduced from 8d. to 4¾d.

Birmingham Electric and Industrial Exhibition.—On the application of Mr. T. C. Sharp, the Board of Trade have certified under the provisions of the Patents, Designs, and Trade Marks Act, 1883, that the Electric and Industrial Exhibition, to be opened at Bingley Hall in August, is to be regarded as an International Exhibition. The arrangements for this attractive event are progressing satisfactorily, and the demand for space gives promise of an unqualified success being achieved. The Exhibition, which will remain open three months, will illustrate the application of machinery to most branches of trade, and will also include electrical novelties of exceptional interest.

Electric Lighting.—The new Salisbury Club, St. St. James's Square, is now lighted by the St. James's and Pall Mall Electric Light Company. The station is at the back of the club in Mason's Yard. The current is low-tension, and the company, having a licence for St. James's parish, maintain that it is better to light in a perfect manner what is in the parish, and not to attempt long distances.

Conversazione at the Ipswich Mechanics' Institute.—On Tuesday evening the committee of the above institution gave a scientific *conversazione* in honour of the lighting of the reading room by electricity. In lieu of the gas burners, the fine reading room is now illuminated by a large incandescent lamp of 200 candle-power which is suspended from the centre of the ceiling and throws a good general light over the book-shelves, and by 10 16-candle-power lamps over the reading tables and stands, and six smaller lights placed in various odd nooks and corners. The installation has been made by Messrs. Laurence, Paris and Scott, of Norwich and Ipswich, under the direction of Mr. W. B. Sisling, and the work has been most effectively carried out.

The Telephone Company of Ireland.—The tenth ordinary general meeting of this company was held on Saturday last at Commercial Buildings, Dublin. The report shows the amount standing to the credit of the net revenue account as £4,643, against £4,314 for the year 1887.

Royce's Dynamos.—Messrs. F. H. Royce & Co., of Manchester, announce that the Acme Electric Works Company are appointed agents for the sale of the Royce dynamos for London and a radius of 54 miles.

Personal.—Messrs. Moody and Andreae have commenced practice as electrical engineers at No. 2, Princes Mansions, Victoria Street. Mr. Neville Moody has for the last five years been with the Anglo-American Brush Electric Light Corporation, Limited, and Mr. Walter Andreae was for over two years in the factory of the Brush Corporation and was afterwards in the employ of Herr Schuckert, of Nuremberg.

The Telephone Amalgamation.—The City article in the *Daily News* of Tuesday contained the following note :—In reference to the amalgamation of telephone companies, which we recently announced, the following is the text of a circular issued by one of the companies concerned—that known as the Lancashire and Cheshire Telephonic Exchange Company, Limited :—

Manchester, *5th April*, 1889.

For the past 18 months your board of directors have been in frequent consultation with the United Telephone Company and the National Telephone Company, with a view to amalgamation. The details of the amalgamation have not been finally settled, but it has been provisionally arranged that the basis of such amalgamation shall be the market value of the respective shares, estimated as follows :—United Company, £15; National Company, £6, and £1 11s. 6d. as the value of each £1 share in the Lancashire and Cheshire Company. When the necessary formalities are completed a circular will be forwarded, inviting you to attend an extraordinary general meeting of shareholders, to consider and (if thought fit) to approve of the draft agreement which will then be submitted. JOSEPH THOMPSON, *Chairman*.

Death of M. Chevreul.—The illustrious French chemist, whose centenary was celebrated with public rejoicings some two years ago, died on Tuesday morning, April 9th.

The New Telephone Company follows the Equitable.—The New Telephone Company has "settled" with the United; that is to say, the former caves in all along the line. The writ was brought on the Edison patent only, against the valve transmitter, and was aimed not merely at the New Telephone Company, but against its directors individually and personally, and this alarmed the majority. Damages at the rate of £10 per instrument were claimed against the company and purchasers alike, also costs between solicitor and client, and the motion, curiously enough, came before Mr. Justice North, who, in the Bassano case, practically decided that everything which vibrates when talked to is a diaphragm. From this it is evident that if the case had been fought, it would have meant carrying it to the House of Lords, and besides the expense incurred in this, there would probably have been a delay of two years, pending which Bell's patent would lapse, and Edison's nearly run out. No wonder then that the majority of the directors thought discretion the better part of valour, and declined to fight for breaking down a monopoly which naturally comes to an end a few years hence. We believe that efforts have been made to arrange settlement on such terms as would protect purchasers from the threatened £10 damages, and also dealers and manufacturers; but as the formal application for an interim injunction comes on this morning, our readers must be content to wait till our next issue for further particulars.

A Paying Concern.—The United Electrical Engineering Company, which is a sort of "Phœnix" risen from the ashes of the nearly forgotten Jablochkoff Company, last week paid a dividend of 5 per cent. to its shareholders. From what we have lately seen of the energy and enterprise of Messrs. Manville and Madgin and the business which is being brought before them, we believe that the time cannot be very far distant when this dividend will be considerably increased.

Not as it should be.—It is said that during the intense darkness of Wednesday no light could be obtained during the day from the Grosvenor Gallery central station, one reason assigned being that the boilers were undergoing the process of cleansing. It is in cases of emergency like this that gas has such great advantages, yet many in the electric lighting business seem to consider that the total deprivation of light when most wanted is a matter of little or no consequence.

Ozokerite.—A provincial paper referring to the use of ozokerite in the United States, remarks :—"In future, however, it would appear that the most extensive consumption of the article will be caused by the manufacturers of *waterproof insulators* for *magnetic wires*, as it is well adapted for the making of such things."

NEW COMPANIES REGISTERED.

Galloways, Limited.—£250,000 in £100 shares. Objects: To take over the business of W. and J. Galloway & Sons, of the Knott Mill Iron Works, Manchester, the Branch Works, Gorton and elsewhere, and to carry on business as engineers, metal workers, electricians and suppliers of electricity for light, heat, motive power or otherwise; to manufacture all kinds of apparatus used in connection with the generation, distribution, supply, accumulation, storage and employment of electricity. Signatories (with one share each): *John Galloway, *John Galloway, jun., *C. J. Galloway, *E. N. Galloway, *A. W. Galloway, *J. H. Beckwith, W. E. Norbury, all of the Knott Mill Iron Works, Manchester; Charles Rought, 64, Cannon Street, E.C. The signatories denoted by an asterisk are the first directors, qualification—50 shares; remuneration of ordinary directors £50 per annum each. The managing directors and their salaries are as follows :—C. J. Galloway and E. N. Galloway, £1,330 per annum each; A. W. Galloway, £840 per annum; J. H. Beckwith, £1,500 per annum. Registered 3rd inst. by C. Doubble, 14, Serjeant's Inn, E.C., as agent for Payne, Galloway & Payne, Manchester.

Northampton Electric Light and Power Company, Limited.—Capital £20,000 divided into 10 A shares and 19,990 B shares of £1 each. Objects :—To generate, produce, store, accumulate and distribute electricity or similar agency for lighting, motive power and other purposes. Signatories (each subscribing for 1 A share and 100 B shares): *R. Cleaver, *H. E. Randall, *H. Manfield, M. H. Holding, all of Northampton; *S. L. Leckham, Lichfield; *D. J. Morgan, 1, St. Helen's Place; P. Phipps, Collingtree Grange, Northamptonshire; *F. H. Thornton, Daventry; *R. E. Bell Crompton, Mansion House Buildings; H. S. Gibson, 4, St. Mary Axe. The signatories denoted by an asterisk are the first directors; qualification, 100 shares. The company in general meeting will determine remuneration. Registered 5th inst. by Deacon & Co., 4, St. Mary Axe.

Mudge-Marchant Engine Company, Limited.—Capital £131,105 divided into 2,610 ordinary shares of £50 each, 50 A shares of 2s. each, and 120 B shares of £5 each. Objects :—To carry on business as mechanical engineers, manufacturing chemists, electricians, and suppliers of electricity for light, heat and motive power, and as manufacturers and dealers in electrical apparatus; to acquire the letters patent the subject of the complete specification No. 6,914, applied for on the 9th May, 1888, by Robt. Mudge-Marchant and Otho Giles. 2,560 ordinary shares are taken up and are held as follows: Major R. Rogers, 80 shares; *R. Ley Wood, 320 shares; G. S. Voile, 40 shares; Mrs. Elizabeth Davies, 40 shares; Rev. E. Crow, 80 shares; T. F. Cottam, 60 shares; E. H. Thompson, 80 shares; Mrs. M. McDonnell, 20 shares; A. Pike, 20 shares; A. A. Phillips, 40 shares, all of Cheltenham; *R. M. Marchant, C.E., Wellington Street, Islington, 1,280 shares; *Otho Giles Abbott, 280 shares; E. A. Davies, Wolverhampton, 40 shares; J. R. Thomas, Exeter, 40 shares; Thos. Norton, 4, Bishopsgate Street Within, 40 shares; Mrs. N. Cook, Oxford, 20 shares; C. H. S. Moon, Gloucester, 20 shares; D. J. S. Hunt, Thorpe, Norfolk, 20 shares; H. P. Heyworth, Lewisham, 20 shares. The members denoted by an asterisk and Mr. Archibald Fairlie are the first directors; qualification, £50 in the capital; the company in general meeting will determine remuneration. Registered 7th inst. by Andrew Wood & Co., 8, Great James Street.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Welsbach and Williams, Limited.—The Chancery Division of the High Court of Justice, by an order dated 30th ult., has sanctioned the reduction of the capital of this company from £40,000 to £34,000, in £1 shares, by the cancellation of 6,000 shares.

Anglo-American Brush Electric Light Corporation, Limited.—An agreement of the 27th ult., filed on the 3rd inst., between this company and Simon Girling, of 3, Woodstock Road, Finsbury Park, provides for the allotment to the latter of two fully paid shares in pursuance of the agreement entered into with the liquidators of the Great Western Electric Light Company, Limited.

CITY NOTES, REPORTS, MEETINGS, &c.

Electrical Automatic Delivery Box Company, Limited.

AN extraordinary general meeting of this company was held at Winchester House, Old Broad Street, on Wednesday, for the purpose of considering a proposal to liquidate the company and to amalgamate with the Automatic Trading Company, Limited. Major Murdoch presided.

Mr. Woodford, the secretary, read the notice convening the meeting, after which

The Chairman said they had been advised to slightly alter the terms of the resolution which had been sent to the shareholders with the notice of the meeting, so that it would read:—"That it is expedient to effect an amalgamation of this company with the Automatic Trading Company, Limited, and that with a view thereto the directors be authorised to take the necessary steps to effect the same." He might say at once that they would not commit themselves to any scheme without first placing the details before the shareholders for their consideration. They had nothing at all of a disappointing character to communicate to the meeting. The capital was all right; it remained pretty much as it was when the present directors took it over. They had incurred no liabilities whatever, and the only deductions to be made, amounting to about £300, were on account of expenses incurred before they came into office. Their subject divided itself naturally under three heads—capital, boxes, and positions. He might say that these three were really one, for if they got capital box positions they would get capital dividends; but if they had capital, boxes, and no positions they could do nothing. With regard to the boxes, it would be remembered that at the meeting in December a report by Mr. Ingrey was read, in which it was said that a model box had been tested and proved satisfactory—that, with the addition of a rejector, it would be perfectly safe from being fraudulently manipulated. The old directors told them that the Carlton Engineering Company had manufactured a model box, and that there were 12 other boxes in an advanced stage. Yet they advised that the company should go into liquidation. He (Major Murdoch) moved an amendment, which was carried, that the company should go on with a fresh board of directors, and that it should have 12 months' trial to see what could be done. A committee of investigation was appointed, consisting of Mr. Gore Booth, Mr. Tom Evans, and himself. They had several long sittings, conferring with the old directors, and eventually they made a report to the shareholders, who approved of it, and appointed the members of the committee to the board, giving them *carte blanche* to set to work on the understanding that 100 boxes should forthwith be placed out. He was sorry to say that they found that the position of a committee of investigation to confer with the directors did not place them in the position of directors and so enable them to command the position. Consequently, when they did become directors they found that all was not of the gold colour they had anticipated. They were not deceived, but they were misled in certain points. Mr. Stead was present at the meeting at which Mr. Ingrey's report was read, and he stated that he knew Mr. Ingrey had subjected the model box to very severe tests, which it stood satisfactorily. The shareholders would now be surprised to hear that when the committee became directors, and asked for the model to be produced, there was no such thing.

Mr. Stead: What do you mean by that?

The Chairman: There was no such model box to take halfpence and farthings. When they went to Mr. Ingrey he said that the diminutive little model which he had seen was not a working model at all, and he would have to make the whole thing over again himself.

Mr. Stead: Very naturally.

The Chairman said they expected to find a box that would deliver penny and threepenny articles, but they did not get it. But it would be done. He was confident that the box was a good one. When he became a director and was appointed to the chair he laid down an injunction that the box which was shown at Cannon Street Hotel should be placed aside and not be touched. He then gave the Carlton Engineering Company the order to deliver the twelve boxes which it was said were in the course of manufacture, and after a very great deal of trouble they obtained four. Then these had to be fitted with the patent rejector by another company, so that they were not ready for use until the end of February. They decided that if these boxes answered their expectations they would get 200 or 300 and put them out; but, unless they could get a model working box that they could test and prove to be the actual thing described in the prospectus, they would not give the order. In January Mr. Ingrey sent an ultimatum to the effect that he would only manufacture the boxes on the understanding that £330 would be paid down with the order. Then came the question of policy. Should they go on experimenting with the box and try to get 100 manufactured; should they call the shareholders together and tell them of the difficulty; or should they do something and ask the shareholders to approve of it afterwards? They decided to do something. The articles of association empowered them either to sell the property of the company to another company, or to amalgamate with any other company. Their policy was this: they would not give the order for 100 boxes, but would see whether they could sell the company beneficially or enter into negotiations for an amalgamation. They communicated with the Automatic Trading Company, and by the favour of that company they got what they would not have been able otherwise to get for any amount of money, positions at the railway stations. The two surviving automatic sweetmeat companies between them absorbed the whole of the Metropolitan Railway stations. By favour of the Automatic Company they were able to put a box at King's Cross. The box used was that which had been produced at the December meeting as a certified working box. This was the result: it delivered two penny articles for one penny; it could be worked without placing a coin in the slot at all. The station master consequently had it put into the cloak room. He did not blame Mr. Stead for this. They had received great assistance from Mr. Stead and his partner, who had promised to inspect and pass the first 100 boxes for nothing. The directors then had the other four boxes fitted with rejectors, which were certified by Messrs. Stead and Hedgman, and the Automatic Company placed one of them at Euston Station. The first day it worked admirably, and took 6s. 4d. The average takings of the automatic boxes were 1s. 6d. per day. Afterwards they took an average of 2s. 6d. a day. On the previous night, however, he received a letter stating that it had broken down, and that several lead discs had been found in it.

The manager of the Automatic Trading Company here explained that someone had broken the glass front of one of the columns, a piece of the glass falling into the drawer and preventing it from working. The mechanism was still in perfect working order. The "lead" discs might not be lead at all; that was the term applied to everything that was not an actual coin, and in this case it might mean brass, iron, or ivory, which the machine would not reject.

The Chairman said he had been convinced by his own experiments that it was impossible to work the apparatus by means of lead discs. Even if people took the trouble to make iron or bronze discs specially to defraud them—he could assure them that it would be a mere bagatelle. The experience of the other companies had been that losses in this way were very slight indeed. With regard to the proposed amalgamation, they could do nothing unless they could put boxes into the railway stations, and this they could not do by themselves. So they were in this position: they had cash and boxes, but no positions. The Automatic Company, on the other hand, had the positions, they had experience and administrative organisation, but in procuring these things they had spent their cash. The proposal was that they should reduce their capital to £15,000, at which figure the capital of this company now stood; both would then go into liquidation, and a new company would be formed with a capital of £30,000, in which shareholders of this company would have share for share. This was but the prelude to greater things, for they would then proceed to further amalgamation, embracing all the automatic box companies, and forming a union which would probably do a business such as few commercial companies were able to do. Two more meetings would be necessary, one for details to be submitted, and another to appoint liquidators. The Chairman concluded by moving the resolution already given.

Mr. Deakin seconded the motion.

A short discussion followed, the shareholders being anxious that the directors should make a close scrutiny of the position and contracts of the Automatic Trading Company.

The Chairman having given the requisite assurances, the resolution was carried unanimously, and the meeting terminated with a vote of thanks to the chairman.

Montevidean and Brazilian Telegraph Company.

THE ordinary general meeting of the shareholders in this company was held April 9th at the offices of the company, 2, Tokenhouse Buildings, under the presidency of Dr. Cameron, M.P. The report stated that the percentage of gross revenue receivable from the Western and Brazilian Company during the past year was £3,604 4s. 2d., as compared with £2,508 9s. 1d. in 1887; and the directors were glad to note that so far as could be judged from the published returns of the Western and Brazilian Telegraph Company, the traffic continued to improve. The directors recommended the payment of a dividend at the rate of 3s. 6d. per share on the preference shares of the company which would absorb £1,454 19s, leaving a balance of £54 15s. 9d. to be carried forward.

The Chairman, in moving the adoption of the report, said it was a more favourable one than that of any previous occasion, which was owing to the improvement in the revenue of the Western Brazilian Company. The company, as the shareholders knew, was bound hand and foot by the agreement with the Western Brazilian Company, and their revenue depended entirely upon that company's earnings. It would be noticed in the report that the auditor stated that the Western and Brazilian Telegraph Company had objected to an inspection of their books, and therefore he had not been able to verify the percentage of earnings

payable to the Montevidean Company. Owing to some looseness in the way the agreement had been drawn up, it was held that the company had no right of direct access to the books of the Western Brazilian Company, and the former company had found that they had no power to inspect them; but since the report was issued the auditor had seen the books of the Western Brazilian Company, and had written a letter in which he stated that the percentage the company were receiving was correct. The directors had been enabled this year to reduce the rate of interest on their debentures. These debentures were issued at a time the Company were in a very embarrassed position, and when they were glad to get money at the very high rate of 8 per cent. interest. The directors had made various offers to reduce the interest on their loan, but found that they were unable to do so. This year, however, a proposition was made which enabled them to refund those 8 per cent. debentures, to call them in, and cancel them, and to issue some fresh debentures at the rate of 6½ per cent. This year the company would not gain anything by the transaction because the directors were obliged to pay a commission, amounting to the difference between the 6½ and 8 per cent., to the gentleman who had carried through the operation, but afterwards the company would be clear gainers by 1½ per cent. on the amount of their debenture debt.

The report was adopted.

Electrical Power Storage Company, Limited.

THE eighth annual meeting of the shareholders of this Company was held at Winchester House on Wednesday, the 10th April, Sir Daniel Cooper, Bart., G.C.M.G., presiding. In taking the report (which appeared in our last issue) as read, the Chairman said: I now propose to offer some remarks and explanations upon the report and the figures in the statement of accounts where they seem to call for observation. During the past year there has been a gratifying increase of business. This increase is mainly made up of a great number of small orders for storage batteries, which are employed for the variety of purposes detailed at length in the directors' report. By far the larger portion of the gross profit of £13,273 15s. 3d. has been earned in the manufacturing branch of the business, as the firms and companies on the continent who have agreed to manufacture "E.P.S." batteries, under royalty, have taken a longer time to complete their arrangements than was anticipated. There is an increase of £165 5s. 9d. in the item of rates and taxes, owing to the payment of income tax. We have not done so much advertising lately, so there is a diminution of £293 6s. 8d. in that account. The shares allotted last year to the managing director have been charged against the reserve at par value. The company has taken out what we believe to be valuable patents, in the United Kingdom and in several continental countries, for improvements in details of arrangement in the E.P.S. accumulator, and also for distributing apparatus in connection therewith, and much time and thought has been given by Mr. Frank King, our chief engineer, and by our technical staff, to perfecting what is commonly known as the E.P.S. system of distribution by storage batteries. On the other hand, law costs and patent fees account is less by £194 2s. 3d., because we have had no professional fees to pay, and are for the present free from litigation. The amount allowed for doubtful debts has proved more than ample for the purpose, and there is a balance over, which we consider sufficient for this year. There has been, as mentioned in the report, some additional outlay owing to the increase of business on the plant and buildings at Millwall works, and further outlay will have to be made this year. The amount under the heading of sundry creditors is larger, but against this is the increase in sundry debtors account, while the cash balance at the bankers is £3,000 more than it was last year. In the report is given a selection from a long list of new electric light installations in which E.P.S. batteries are used. Reference is also made to various scientific and technical institutions which have adopted accumulators, and I do not think I need here enumerate them. You will have noticed that E.P.S. storage batteries are now used for all kinds of purposes—train lighting, ship and yacht lighing, omnibus and carriage lighting, and for power in tramcars, electric launches, and again for surgical purposes. In short, their use is becoming general, as you will have gathered from the paragraphs which have appeared in many newspapers during the past year, and you may take it that though the name of the E.P.S. Co. has not always appeared, yet in 99 cases out of 100 the batteries were the E.P.S. type. Among the latest interesting applications of batteries I would mention the printing at the office of the *East Anglian Times*, at Ipswich, by power supplied by E.P.S. batteries, which are placed at the central lighting station of Messrs. Laurence, Paris & Scott, Limited, in that town, a description of which was sent to the shareholders with the report. I must now dwell for a moment on the subject of central station lighting, the importance of which to this company cannot be over-stated. The company has applied for provisional orders for Paddington, St. Martin's, and the Strand Districts, and an enquiry is now being carried on under the instructions of the Board of Trade, upon questions which relate to the whole of the applications for provisional orders in the Metropolis; I shall refrain from making any observations thereon, as the matter is still "*sub judice*." I will now pass to the Chelsea Electricity Supply Company, which is supplying light in the Parish of Chelsea. You may not be aware that this is the first company which has supplied electric light in London under the statutory powers of a provisional order. It has acquired these powers by Act of Parliament Vic. 50, cap. 18. The E.P.S. Company in conjunction with the Anglo-American Brush Company, and the Callender Bitumen and Telegraph Company, took up the Chelsea Company last July, and contracted to furnish the necessary plant, and they have now carried it through to its present stage; and I feel confident that the combined efforts of the three companies, each in its own special line, will result in a model central station. The system of distribution is that of the E.P.S. Company, by which the current is supplied from the main station to storage batteries placed in convenient sub-stations throughout the district to be supplied. We believe this system to be the best for such populous districts as Chelsea, and that the public will give the preference (when once they become acquainted with its essential features) to the only system in which a reservoir of light, in case of accident from any cause whatever, is provided. Our managing director, Mr. Courtenay, is a director of the Chelsea Company, having joined the Board at our request. You will perhaps have read the pamphlet issued by the Electrical Accumulator Company of New York. I need only remark that judgment has now been given against the Julien Company for infringing the Faure patent, and therefore that company will be put under injunction. The trial of this suit has taken more than twelve months, and the investigation has been one of a most searching and exhaustive character. The shrewd advisers of the American Company consider, as they state in the document referred to, that they had already got the control of the accumulator business in the States from their other patents, even without the Faure patent, and now that they have this basic patent also declared valid, their position should be doubly assured. I beg to move the adoption of the report and accounts, and ask Mr. Sellon to second the resolution.

Mr. Sellon said: I have little to add to the remarks of the chairman, or to the matters dealt with in the report. It would, of course, have been gratifying, and doubtless acceptable, if they were able to recommend a dividend, and one large shareholder has remarked to me that if they had declared one their shares would have doubled in market value. In my opinion, in view of what was before them, I see no reason why they should not quadruple in value. It has been a labour of years building up the business, overcoming violent antagonism, and establishing the secondary battery upon a firm basis as an indispensable, reliable factor, in electrical lighting. Having achieved this, I consider it would be unjustifiable to do anything which might cripple the company in the work they have before them. In a growing company of this kind every thousand pounds is of value, and I might mention that the directors have not for two years taken out their well-earned fees. On former occasions I have dealt exhaustively with the technical questions in connection with this undertaking, and I have already pointed out the wide and extensive range of work which lies before us. The chairman has alluded to a recent important decision given in the Courts of the United States in favour of the Faure patent. With the exception of one decision relating to the Thomson-Houston patent this is the only litigation in the United States which has terminated favourably for the patentee. The Faure patent is held by the Electrical Accumulator Company, of America, a powerful corporation formed to work the company's patent rights in the United States, in which we hold a very considerable interest. The importance of that decision will be obvious when I explain that this patent entirely controls the use of active material applied to the plates. I would also mention that the Swan patent for the perforation of the plates came before the same Court and was not upheld, but the decision did not arise from any invalidity of the invention itself, but upon a matter of form, proof not having been put forward as to its priority, through some oversight as to the earlier date of the English patent compared with that taken out in the United States. If considered necessary this could doubtless be put right, and its priority, which is incontestable, can be established. Of course, neither here, nor in any other country where we hold patents, is the Swan patent in any way affected by the decision of the United States Court. I will take this opportunity of explaining that the shareholders possess in the E.P.S. group of patents some forty of more or less important value, covering each and every point of detail essential to the business, and, so far as I know, there does not exist a single outside patent which will be of use in our work. Several of the patents are, as in the case of the Faure, governing or controlling patents, in the sense that no economical and efficient secondary battery can be constructed without infringing them. Every perfect plate made embodies the principles of no less than four of these patents in its manufacturing. Then, as several patents are of recent date, they have the advantage of prolongation of the term of the monopoly of manufacturing storage batteries, because naturally the most perfect battery is the one which will command the market. You will therefore feel justified in considering your position in this important and indispensable branch of the electrical industry to be not only unique but unassailable. I would also add that as time passes and experience is gained the more absolute will be the confirmation of the views put forward by myself and others some eight years ago, but doubted and criticised at the time by many electricians, that it is to the employment of the secondary battery that we must look for the attainment of the most reliable, safe, economical, and generally acceptable system of electric light. I confidently anticipate that one of the results of the important investigations at Westminster Hall will be that electricians and the general public will be able to vividly realise the solid and paramount advantages of the storage system which this company advocates and controls. I have great pleasure in seconding the adoption of the report.

Mr. Schomberg said when he read the report of the company he naturally hoped there would be a little return, and considered there should be a dividend of 2½ per cent.

Mr. J. W. Barclay, M.P., thought it would be a misfortune if they were to starve the company. He considered the capital was inadequate for fully developing the business, and it would be unwise at present to declare a dividend.

Mr. J. I. Courtenay (managing director) said a scheme for the raising of further capital would be brought forward during the year.

The motion was then carried.

Mr. Barclay moved that Sir Daniel Cooper and Mr. J. I. Courtenay, the retiring directors, be re-elected. Surgeon-Major de Tatham seconded the motion, which was carried unanimously.

Mr. Grindle moved that the retiring auditors, Messrs. Deloitte, Dever, Griffiths & Co., be re-elected.

Mr. Schomberg seconded, and the motion was carried.

The customary vote of thanks was passed to the chairman, and the proceedings terminated.

The Eastern Extension, Australian and China Telegraph Company, Limited.

THE thirty-first general meeting of this company was held on Wednesday, 10th April, 1889, at Winchester House, Old Broad Street. Sir John Pender, K.C.M.G., in the chair.

The minutes of the last meeting were read and confirmed.

The report was then taken as read.

The Chairman said, before I ask you to approve of the resolution which I shall submit for the adoption of the report, I will make a few remarks. I am sorry I cannot congratulate you upon a brighter day, but I hope the accounts to be placed before you will to some extent compensate for the dull day we are experiencing. The gross receipts for the half-year amount to £238,854 against £232,660 for the corresponding half-year, which show an increase of £6,194. That might have been considerably increased had it not been for the unfortunate interruptions of the Australian section. In addition, there has been a heavy loss of £6,947 in exchange, in consequence of the increased depreciation of the silver currency. The latter, of course, could have been diverted by collecting larger payments from the telegraphing public, but as this would be practically increasing the tariffs, the company did not wish to resort to such a step if it could be avoided. The working expenses for the half-year is £71,519 against £69 570 for the corresponding period of 1887, which shows a balance of £1,949, this being due to the fact that the cost of repairing cables has been heavier during the past half-year than in 1887. The figures for the whole year are as follows: gross receipts in 1888, £478,780 against £451,861 in 1887, which shows an increase of £26,919, or over 1 per cent. on the whole share capital, the working expenses for the same period gives a decrease of £4,900; 1888, £140,911; 1887, £145,811, saving £4,900. An interim dividend of 1½ per cent. has been paid for the half year, and we propose to pay a like amount on the 15th inst., which will make, with the interim dividend for the first half year, a total dividend of 5 per cent. for the year. We also propose to distribute a bonus of 3s. per share, which will make a total payment of 6½ per cent. for 1888. The balance of £66,101 has been carried to the reserve fund, which stands at £690,454, as shown by the following figures:—Amount of fund at the end of 1887, £620,095; interest added during the year, £23,244; balance of revenue, £66,101; total, £709,440, leaving a balance of £690,454, in addition to which £15,401 has been charged against revenue, for the completion of the renewals of the Singapore-Saigon cables, and £4,492 for rebuilding staff quarters at Cape St. James. The net result, therefore, of the past year is that the reserve fund has been increased by £10,359. The cost of the renewals of the Singapore-Saigon and Java and Australian cables, with the rebuilding of the staff quarters at Cape St. James, amounted altogether to £38,879. It will be seen that further drawings of the company's 5 per cent. debentures have taken place since the close of the half year. No provision has, however, been made beyond the £320,000, 6 per cent., falling due in 1891. I hope to be able to put a scheme before you later in the year, which will deal with these debentures. Since the close of the year the laying of the new cable between the Java and Western Australia has been successfully completed. This extension, which gives the colonies a third cable to Java, and brings into use the Western Australian land lines as an alternative system of the South Australian overland lines was not needed to meet traffic requirements, the existing cables between Java and Port Darwin having a large margin of carrying capacity, but to strengthen the system and minimise as far as possible the risk of interruption in the future. The cost of the new cable, about £130,000, will be dealt with in the current year's accounts. As stated in the report a satisfactory arrangement has been concluded with the colonies of Tasmania, for renewing the exclusive provision of telegraph communication between Tasmania and Australia, which by effluxion of time would expire next year, and for continuing the subsidy of £4,200 a year for the same period. For some years previously, differences of opinion has existed between the Government and the company as to the interpretationof the contract in regard to the payment of the subsidy after the termination of the 20 years' concession. The company contending, with the approval of eminent counsel, that, by the terms of the contract a subsidy was payable in perpetuity so long as the communication was efficiently maintained, whereas, the Government argued that the obligation must cease with the concession. Negotiations, however, were eventually entered into with a view to averting the unpleasantness and uncertainty of legal proceedings, and the following agreement was arrived at, which will secure the company's position for the next 20 years, i.e., the exclusive concession is extended for a further term of 20 years, the subsidy is continued for the same period, a traffic guarantee of 5,600 given by the Government, and the company is exempted from all taxation and duties chargeable to the colony. This arrangement has been ratified by the Tasmania legislature and embodied in a formal agreement exchanged with the Government, so that all differences with the colony are now satisfactorily adjusted. I have now given you a full and accurate statement, showing what we have done, and probably nothing we have done has given more satisfaction than the prompt way in which we laid down the third cable to Australia. I have very little more to say on this occasion, probably I never had so little, because everything is going on satisfactorily. As I have said, when a break occurs it does not alarm us much, the only thing is the loss of time, and the small cost in repairing. I might mention that in all general meetings we generally have some shareholder who takes a greater interest than another, as to what the directors ought to do at a general meeting; as a rule, this interest refers to the dividend they ought to pay, and a great many people suppose that in the midst of our prosperity we ought to go on increasing our dividends. I have been asked why we are paying 2 per cent. bonus this year instead of 2½. I have shown that we have taken this year out of the revenue an amount which far exceeds the half per cent. bonus referred to. We did pay at one time the additional half per cent., but when I told you that, in the face of the extra repairs, and that next year we may come face to face with the Conference in Paris, when the question of our rates and tariffs will be again discussed, it would not be wise to do so at present. We had to make considerable sacrifice at Berlin, and we may be called upon to make considerable sacrifice at Paris. We have recouped to a great extent what we gave up at Berlin, and I have no doubt we shall do the same at the next conference. Of course, we can make a better battle if we have a good reserve at our backs, and therefore you must bear in mind that if you do not get your additional bonus in money, you get it in the increased value of your shares, and it is difficult to have it both ways. I now beg that the report be adopted, and that a dividend of 2s. 6d. per share, together with a bonus of 3s., both free of income tax, payable on the 15th inst., making a total of 6½ per cent., be declared.

The Right Hon. Viscount Monck seconded the motion, which was carried unanimously.

Sir James Anderson and Francis Augustus Bevan, Esq., the retiring directors, were re-elected, as also were the retiring auditors.

A vote of thanks was passed to the chairman, which brought the meeting to a close.

Reuter's Telegram Company.—The report of the directors of this company states that the net profits for the year 1888 amount to £1,222, including £61 brought forward from the last account. In accordance with the articles of association, the directors have transferred £3,449 from the reserve fund, of which £538 is applied to extinguish bad debts, and the balance of £2,911 is carried to profit and loss account. From the amount thereby made available for distribution the directors declare a dividend of 5 per cent. for the year 1888. This will absorb £3,687, and leave a balance of £446 to be carried forward.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending March 29th, 1889, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £3,933.

The Great Northern Telegraph Company, Limited. The receipts in March, 1889, £21,000; January 1st to March 31st, 1889, £63,000; corresponding months, 1888, £63,800; and of 1887, £61,200.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the week ended March 29th, amounted to £5,351.

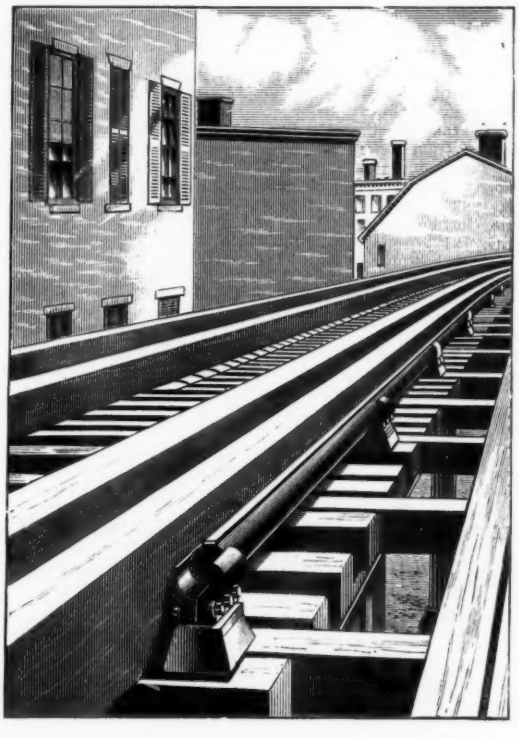
LEGAL.

United Telephone Company v. Siemens Brothers, Limited.—Mr. Justice North made an order in this action on Monday, the 8th inst., restraining the defendants from infringement of Prof. Graham Bell's patent for the magneto-telephone. It appeared that the defendants had supplied instruments, manufactured by Messrs. Siemens and Halske, of Berlin, to certain persons in this country, and among others to Messrs. Lucas and Aird, on account of the War Department for use on the proposed Suakin-Berber Railway. This railway was not proceeded with, and the instruments were brought back to this country and were recently put up for sale by the War Department. The United Telephone Company immediately gave notice that they should take proceedings against any person purchasing and using the instruments, and they subsequently took action against Messrs. Siemens Bros., Limited, for having imported the instruments from Germany

and sold them in this country. The defendants admitted the infringement, but pleaded that they had acted inadvertently, and under these circumstances an injunction was taken by consent, the defendants paying the costs of the action and nominal damages, &c., the offending instruments (which had been recovered by the defendants from the War Department) being surrendered to the plaintiffs. We understand that this is not the first time that the War Department has taken the somewhat high-handed course of ignoring a patentee's rights. It is, of course, necessary that the department should be entitled to require a supply of instruments for the public service, and this is provided for by the Patent Act of 1883, which compels the Government to respect all patents issued after the date of that Act, but we have reason to know that the United Telephone Company had offered to supply to the War Department any instruments they might require at the price at which many hundreds have been supplied to the Postmaster-General and to the Admiralty.

ELECTRIC PROPULSION ON THE NEW YORK ELEVATED RAILWAYS.

THE recent quantitative experiments with the Daft electric locomotive "Benjamin Franklin," on the Ninth Avenue line, have shown such eminently satisfactory results that steps are now being taken to extend the scope of the present service, both as regards distance of transmission and tractive power, and the accompanying view, taken looking southward from Fourteenth Street, illustrates what has been accomplished up to date. It shows the new conductor, wrought iron and phosphor bronze, of sufficient dimension for the entire present or prospective work done upon the line that is now being laid, with all possible despatch, from Fourteenth Street southward to Rector.



Before proceeding to a specific description of the conductor, some further allusion to the above-mentioned experiments will be of interest. They were for the purpose of ascertaining with the utmost possible accuracy the work done at any instant upon the track in the matter of overcoming rolling and gradient resistance under great variation of speed, load, &c., and of comparing the results with the steam power being developed at the generating station at the same instant.

Traces on cross-section paper of the lines representing the primary steam power, the speed of the train, and the gradient of track—in combination with the known load hauled in each case—open an economic vista in railway propulsion that has only been dreamed of hitherto. The time occupied in putting the train at schedule speed from a position of rest was, it may be stated, found to average 20 seconds.

The new conductor is of a circular section, 3 inches in diameter, and capped along its upper longitudinal element by a bar of phosphor bronze, an inch wide and three-eighths deep, which assures a polished surface of contact under all conditions of weather. The different expansions of the two metals are compensated for by a proper introduction of slip joints. The device which secures this beam—no other name seems exactly applicable—in position is a cast iron clamp 5 inches in length, enveloping about two-thirds of the circumference, and with one side detachable. This is skirted with sloping sides, which afford a dry area beneath in all weathers, and materially enhances the insulating quality. The next component is a hard rubber screw plug tapped into the skirted clamp and followed by a hard rubber ring, which rests upon a hollow pyramidal base of cast iron, surmounted by a strong screw nipple, which taps into the described hard rubber cup and binds all parts in one. A tap bolt from beneath through the sill enters a central boss in the hollow base and secures the whole construction in position.

The change from copper to iron is a purely financial move, as even the sixfold increase of area necessary to preserve the same conductivity still leaves the cost far below that of copper. The special interest attaching to this development of electric railway propulsion lies in its connection with the immediate pressing necessities of the elevated lines, which are indisputably at the ultimate of their carrying capacity under the present—or, in fact, under any, except an electrical—system. More trains cannot safely be run. Larger trains cannot be drawn without heavier locomotives, and these, if steam be used, the structure will not permit. The traffic of last year exceeded 170,000,000 passengers, and the average annual increase for recent years has been 15 per cent. There is no promise of relief in any direction except in the superior adhesion of wheels to rails of electric locomotives. Where the track constitutes part of the circuit this is most surprising. While no methodical investigations of it have been made so far as known, due to the general phenomenal obtuseness respecting the importance and scope of this property, it may be stated that the following test in the presence of a number of unimpeachable technical and non-technical witnesses is on record. An artificial gradient of 2,900 feet to the mile was constructed, and a small motor-car carrying a man, and without the advantage of starting upon a level, mounted this, solely under the influence of electrical current and entirely by natural adhesion, as often as desired.

The average steam locomotive on the ordinary track has an adhesion to the rail of 30 per cent. of its weight, with the track either clean and dry or very wet; but this in foggy and frosty weather will frequently be reduced to 15 and 10 per cent. Just what the adhesion of electric locomotives would be under these conditions there are no systemised data to show, but the conviction of its existence is strong enough with the Daft Company to prompt it to construct an electric locomotive of 240 H.P. and 17 tons weight for the purpose of hauling eight loaded passenger cars upon the elevated railways, and its appearance on the Ninth Avenue line may shortly be looked for.—*Electrical World.*

NEW SUSPENSION SWITCH.

WE have before us a new switch for use with suspension lamp-holders, which has merits in several ways. It is a one-handed pressure switch, and can be reached at a higher position than when the other hand is required for steadying while a button is turned. Its mechanical arrangement is fair; a bar at the end of the lever, moved by the press button, flies into or out

of two pairs of spring jaws, thus giving a double make and break with quick action. The whole is neat and of good appearance, while it saves the cost of the wiring to a switch on the wall.

A special ornamental shade carrier is also brought out by the Walsall Electrical Company to suit this switch and holder, the curled springs above the shade adding much to the appearance, and the bayonet ring arrangement below affording a ready means of supporting the shade without the usual screwing action.

The same manufacturers are bringing out a cheap ornamental lamp-holder for socket lamps. This has a reeded boss surmounting the usual bayonet tube, and is made with side connections, or the usual interior binding screws. As the contact points are strong this class of holder will doubtless suit all classes of installation.

ELECTRIC LIGHTING IN MIDLOTHIAN.

A VERY interesting and successful installation has been carried out at Inveralmond House, Cramond, Midlothian, the residence of Mr. G. D. Mackay. The power for driving the dynamo is taken from an old water wheel about 300 yards from the house. The shunt wound dynamo used is a No. 3 "Manchester" machine—Mather and Platt's—capable of an output of 35 ampères and 85 volts, at a speed of 1,100 revolutions per minute. The commutator bars are of drawn copper, wide section, and insulated with mica. The brushes are adjustable with spring forward thrust and hold off catch. The waterwheel, which is undershot, turns a counter-shaft, from which the dynamo is driven. The main cables of W. T. Glover & Co.'s manufacture are carried underground in wooden troughing, thoroughly well tarred, a distance of 300 yards from the dynamo to the accumulators, which are placed in an outbuilding of the mansion. It is satisfactory to note that although the installation has been recently completed, the underground cables were laid more than twelve months ago, and at the present time, after careful tests, give very high insulation results. The battery of accumulators consist of 32 cells of 23 plates each, capable, when fully charged, of maintaining 45 lamps nine hours at full power.

They are of the latest type, grid plates, and their efficiency is high. The installation consists of about 100 lamps. The electroliers and brackets are of specially elegant design, and the work has been done in a very complete way. A special system of safety fuses is used throughout, one being provided to each light and also at all the points where branches are taken from the mains. To enable the necessary connections to be made in the circuit a switchboard, specially designed, is placed in a convenient position, to which is attached a voltmeter and ammeter, and also an automatic switch to prevent the current reversing. The arrangements are altogether very complete and satisfactory. The work has been thoroughly well carried out by the Manchester Edison-Swan Company, under the specifications and personal supervision of Mr. W. A. Bryson, consulting electrical engineer, of Glasgow.

ELECTRIC LIGHTING AT BRIGHTON.

AT last week's meeting of the Brighton Town Council, the Gas Committee reported that a letter had been received from Viscount Torrington, chairman of Crompton & Co., Limited, inquiring whether the committee would be willing to consider a scheme for lighting Brighton by electricity. The committee decided to reply to the effect that they were not at present disposed to consider a proposal of that description. On the matter being discussed by the council,

Councillor BLAKER thought it was a pity that the committee had not given the subject more consideration. The committee was formed, not only for looking after the gas interests, but for considering the best means of lighting the town. If any advantageous scheme were propounded, he thought it ought to receive their most careful consideration.

Councillor DELL said he understood that Viscount Torrington was about to visit the town to hold a public meeting, and he trusted as many members of the council as possible would make it convenient to attend.

The action of the committee was confirmed.

At the same meeting the TOWN CLERK announced the receipt of a letter from Messrs. Rees and Frere, enclosing copies of replies to the last communication of the Brighton Electric Lighting Company for a provisional order, under the Electric Lighting Acts, 1882 and 1888, together with a letter from the Board of Trade, intimating that they had appointed Major Marindin, C.M.G., R.E., to hold an inquiry into the subject of the application at Brighton on April 11th. It was resolved that the Town Clerk, after receiving Messrs. Rees and Frere's opinion, should confer with Mr. Woolley, the Town Clerk of Hove, and co-operate with him if possible, and in the event of the Town Clerk deeming it advisable for the corporation to appear before the Board of Trade inspector at the local inquiry to be held on April 11th next, he should be instructed to take all the necessary steps for that purpose, and have power to retain counsel and witnesses.

These proceedings were also confirmed.

ARC LAMPS AND THEIR MECHANISM.*

By PROF. SILVANUS P. THOMPSON, D.Sc., M.I.E.E.

(*Continued from page* 363.)

PRODUCT REGULATION.

Before passing away from the feeding mechanisms, we may return to the question of regulation in general, and in particular to the point that the function of the mechanism of the lamp is to maintain constant one of the two factors of the electric energy, the dynamo being responsible for the other. That part of the electric mechanism which controls the feed is responsible for the steady working of the lamp; and it is this which has to be sensitive to the fall of the current (in constant potential lamps), or to the rise of the potential (in constant current lamps). It is this which must control the feeding mechanism of the lamp. It may be remarked that the striking electromagnet represents the muscle of the lamp, but the feeding electromagnet represents the brains. Now, if the brains of the lamp have to think about, and control, one factor in the product, why can they be not made to think about and control the product itself? Such a lamp, in which

* Read before the Society of Arts on Wednesday evening, 6th March, 1889.

the controlling part is neither an ampèremeter (main circuit) device, nor yet a voltmeter (shunt) device, but a wattmeter device, ought to make the lamp independent of any fluctuations in the supply. Product regulation is clearly in the abstract better than regulation either by the ampères alone, or by the volts alone, or by the difference between them; and the mechanism is certainly such as can be constructed. Such a lamp ought to run on any circuit. Let it be remembered that on a constant potential circuit a shunt magnet can do no more than a spring might do. Neither can a main circuit magnet in a constant current circuit do more than a spring. A lamp in which both coils are properly combined, ought to be capable of working on either kind of circuit. Indeed, there are some existing lamps which will very nearly do so.

Relay Lamps.

It is evident that the brains of the lamp need not necessarily be placed inside the lamp itself; the device of using a sort of *relay*, outside the lamp, to watch the lamp and control its feed, is one that has been frequently suggested [Crompton, Abdank, Gerard, &c.]. There is one lamp [Jolin, 2570, 1883], in which a shunt relay, itself too weak to move the feed tilting plate, does the work by opening and closing one of the circuits of a double, differentially-wound, main circuit electromagnet.

Retarding Mechanisms.

It would be very easy to write a whole chapter on fans, air dash pots, glycerine dashpots, and the innumerable devices which have been tried. Two are worthy of mention, namely, Hopkinson's device [153, 1881] of altering the rate of feed by raising or lowering mercury in a vessel in which a fan is continuously rotating, and Brockie's suggestion of a liquid brake wheel containing internal partitions, communicating by small apertures, so that a liquid could flow but slowly from one chamber to another.

Replacement Mechanisms.

These may be classified as follows:—

(*a*.) In rack train lamps, a ratchet wheel on first or second member of train.

(*b*.) In clutch lamps with loose clutches, none required.

(*c*.) In forward feeding clutch lamps, some device for loosening the clutch.

(*d*.) In screw feed lamps, some device for unclamping the screw gearing.

Focussing Mechanisms.

The various ways of giving to the carbons the desired differential rates of approach are best classified by reference to fig. 24, which

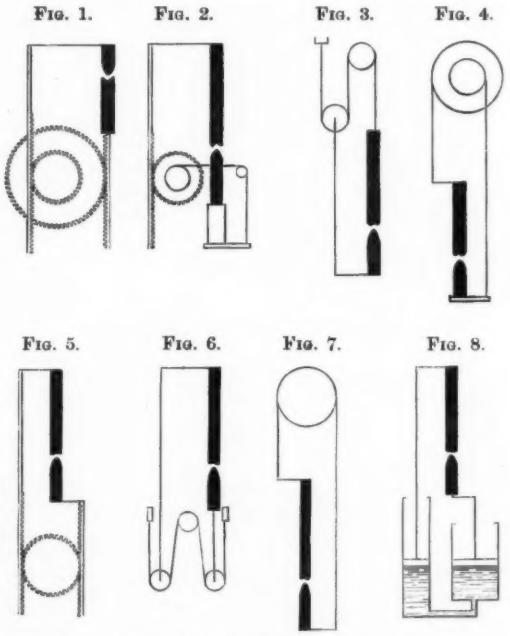


Fig. 24.—Modes of Focussing.

gives four methods of producing a motion of the carbons in the ratio of two to one, and four methods of "commercial focussing," in which the carbons are moved toward one another at equal rates.

Change-over Mechanisms.

These may be classified into those which are purely mechanical [Brush, Thomson-Rice, Bürgin, Crompton-Crabb, &c.,] and those which are electrical, the current being switched off from one pair of carbons, and switched on to another [Weston, 1,163, 1882; Waterhouse, 5,185, 1881; Trott and Fenton, 6,910, 1887; Noble, 16,376, 1887; &c.]

Cut-out Mechanisms.

"Cut-out" mechanisms may also be purely mechanical; but they are more usually electrical, and, in modern forms, enable the lamp to "cut-in" again on the re-establishment of its proper circuit. Cut-outs which enable a shunt-magnet to strike and feed the arc are described by Lever [8,443 1884, and 11,501, 1884], and are used in the Thomson-Rice lamp. The latest devices are those of Lauckert [5,707, 1887,] and Phillips and Harrison [7,235, 1887.] In many lamps the cut-out circuit is merely a shunt electro-magnet stiffly set, which, on the failure of the lamp, receives the whole current, and pulls over a cut-out switch. Gerard [4,792, 1881,] describes several such devices, as well as a cut-out depending on expansion by heat. In the Pilsen lamp (fig. 21), the cut-out is in an auxiliary main circuit. Cut-outs depending on the fusion of a wire or of a washer have been proposed by Lontin [2,094, 1877,] Basilevsky [5,026, 1884,] and McDill [1887.]

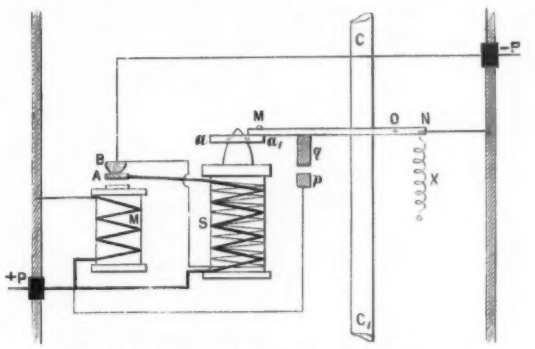


Fig. 25.—Circuits of Thomson-Rice Lamp.

The action of change-over and cut-out mechanisms is well illustrated by reference to the Thomson-Rice lamp, of which fig. 25 illustrates the electrical mechanism, and fig. 26 the mechanical mechanism of the lamp. The terminals are marked + P and − P. The carbon rods, C, C, and C_1, C_1, are held up by their respective clutches, which are identical with those of the Thomson-Houston lamp (fig. 14) already described. The clutches, when the lamp is not at work, are themselves held up by the spiral springs, X, X, which push down the levers, J and J_1, and push up the arms, H, L, and H_1, L_1, so gripping the rods. The principal electro-magnet, S, with its conical poles, has a pierced armature, *a*, *a*, mounted on the end of a strong lever, M, N, (fig. 25), which is pivotted at O, the short tail, O, N, being pulled down

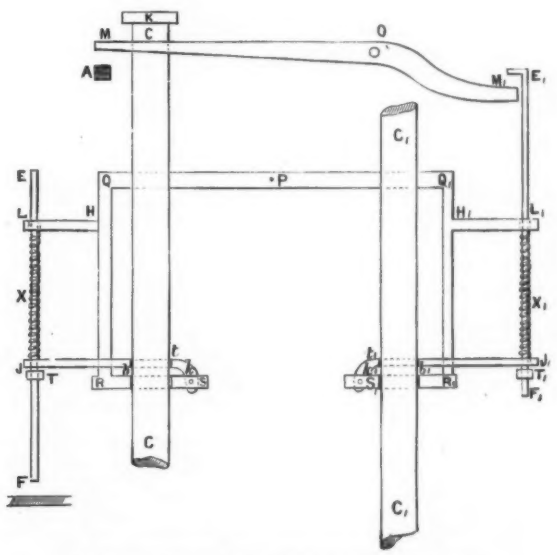


Fig. 26.—Mechanism of Thomson-Rice Lamp.

by a powerful spring, X. This lever, thus held up above the poles of the electro-magnet, is connected to point P (fig. 26) of the clutch frame, and holds it up. The adjusting nuts of this frame are so set that when P descends the lower end, F, of the pin, E, F, strikes on the base plate and opens the clutch for the left carbon rod, so striking the arc of this pair of rods. When the pencils of this side are consumed, the rod, C, C, has descended so far that its projecting head, K, strikes the long lever, M, M, the other end of which raises the pin, E, F, so bringing the other clutch into action. The electric arrangements, fig. 25, are as follows:—The magnet, S, is wound with a few turns of thick wire, and with many turns of

fine wire. The cut-out (or cut-in) magnet, M, is wound with coarse wire only. The upper carbon rod is connected electrically to the frame of the lamp, whilst the lower carbon, insulated from the frame, is joined by a wire (not shown in the figure) to the negative pole. The current entering at + P passes first round the coarse wire on S, most of it going through A and B (which are in contact), and on to − P; but a little of it, after traversing the coarse wire coil, turns back along the fine wire coil and goes by this by-pass route to B and − P. As a result, the armature is strongly attracted, and the lever, M, N, descends, causing the carbon rod to drop. This now opens another route for the current. Starting at + P, some of it will flow through, M, to the frame, thence through the upper and lower carbons and so to − P. This current will attract the armature, A, and break the contact between A and B, breaking the coarse wire circuit through S, leaving the fine wire path still available. Consequently S loses most of its power, and the spring, X, pulls up the lever, M, N, so striking the arc. The shunt circuit (fine wire) through S is still at work, and continues to operate the feeding, increasing as the resistance of the arc lengthens.

APPENDIX.—SAMPLE OF FILLING UP OF SCHEDULE.

Schedule of Arc Lamp Mechanism.

Name of Lamp.—Thomson-Houston. Single arc.
Nature of Supply.—Constant current; ampères 9·8.
Resistances.—Main circuit coil, 0·09; shunt, 279; cut-out 0.85 ohms.

A	Driving power ...	Gravity on upper carbon rod.
B	Striking	Main circuit electro-magnet attracts lower end of see-saw, lifts clutch.
b	ditto adjustment ...	(1.) Special resistance coil shunting main circuit coil. (2.) Spring on tail of clutch.
C	Feeding	Shunt electro-magnet attracts upper end of see-saw, lowering clutch.
c	ditto adjustment ...	Same as *b*.
D	Moderating	Air dash pot on horizontal tail of see-saw.

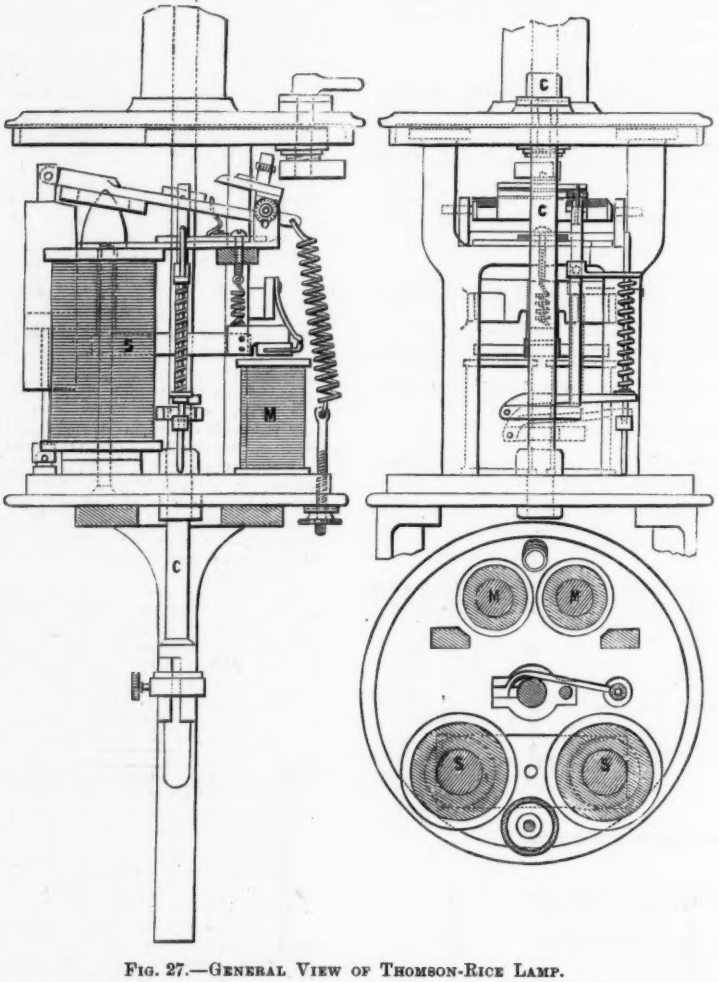


FIG. 27.—GENERAL VIEW OF THOMSON-RICE LAMP.

M. The cut-out (or cut-in) electro-magnet which opens the contacts of the coarse wire winding on the electro-magnet, S.

S. The principal electro-magnet, wound with fine and coarse wire. The armature of this electro-magnet is attached to a lever pivotted at O, and held at its other end by a strong spiral spring. This armature, in sinking, opens the clutch, and, in rising, closes it on the carbon rod which it raises.

The present attempt to furnish a classification of the various mechanisms, electrical and mechanical, of the arc lamp, is probably extremely imperfect, but it may at least claim to supersede the the old and ludicrous division of lamps into "monophotal" and "polyphotal." In conclusion, it may be pointed out that there exists a curious sort of family likeness between the several members of the three species of lamps most in use. The rack train lamps, which may be considered as the prevailing continental type, are for the most part, in their design and construction, essentially clockmakers' lamps; they have a horological aspect. The clutch lamps so universal in America have a sort of sewing machine look, the working parts being only finished where necessary for actual work, all else being left rough or merely painted over. The clutch wheel lamps favoured by British inventors have, in contrast to these, a look as though they had been designed and constructed by a trained engineer; they are essentially engineers' lamps.

E	Replacement	None required.
F	Focussing	None.
f	ditto adjustment ...	None.
G	Change over	None.
H	Cut out	Insulated contact on lower end of see-saw, pulled over by shunt coil, and puts cut-out resistance as shunt from + to − terminal.

Royal Society.—A lecture on "The Magnetic Survey of the British Isles for the Epoch, January 1st, 1886," was to have been delivered on April 11th by Prof. Rucker, F.R.S.

ITALIAN SUBMARINE CABLES.

THE following table shows the cables laid on the coasts of Italy, between her islands and in her African possessions :—

Between Government cables.	No. of conductors.	Length. N.M.	Remarks.
Calabria-Sicily (Bagnara and Torre di Faro)*	1	9·036	Maintained by The Govt.
Pozzuoli-Procida	1	1·808	„
Procida-Ischia	1	2·541	„
Sardinia-Carlo Forte	1	3·735	„
Sardinia-Island of Maddalena	1	1·059	„
Piombino-Island of Elba	1	5·940	„
Sicily-Favignana	1	5·212	„
Capri-Cape Campanella	1	4·925	„
Sardinia-Asinara	1	1·078	„
Venice-Chioggia	1	1·894	„
Otranto-Vallona	1	51·348	Pirelli & Co.
		86·907	
Laid on behalf of Government.			
Calabria-Sicily † (Cannitello to Granzirri)	2	2·781	East. Telg. Co.
Do. ‡	3	2·253	„
Do.	3	2·283	„
Do. §	3	2·344	„
Do. (Bagnara to Torre di Faro)	3	7·287	„
Do. do.	3	7·962	„
Do. do.	3	8·479	„
Orbetello-Sardinia	1	118·379	„
Lipari-Sicily	1	23·927	„
Lipari-Salina	1	5·967	„
Massowah-Assab	1	278·454	Pirelli & Co.
Assab-Perim	1	54·658	„
		515·302	
Between property of other Governments or companies.			
Livourna.Corsica (French)	1	57·837	
Sardinia-Corsica (French)	1	13·513	
Sicily-Malta ‖ (East. Telg. Co.)	1	56·593	
Do. „ „	1	61·621	
Otranto-Corfu „ „	1	64·864	
Otranto-Alexandria „ „	1	936·015	Touching at the Islands of Zante and Candia.
		1190·983	

* Interrupted since April, 1887.
† „ „ January, 1885.
‡ „ „ April, 1884.
§ „ „ November, 1885.
‖ „ „ February, 1878.

AMERICAN NOTES.

By DAS TELEPHON.

THE most important event in the United States, interesting to inventors and patent agents here, and also in Great Britain and other countries, is the dismissal of J. Benton Hall from the Patent Office, and the appointment of Mr. Mitchell, who is a patent attorney, living in New Britain, Conn., to be Commissioner of Patents. He is about 45 years of age, and is well known throughout New England. He was backed by the Connecticut Delegation and by a large number of patent lawyers in New York and New England.

There is great rejoicing here among the patent attorneys over this appointment of one of them to this important position. This is the first time since the creation of the Patent Office that a man experienced in preparing specifications and in patent law has been made Commissioners of Patents, and the confraternity of patent agents throughout the land are having a grand jubilee, as well on account of the exodus of J. Benton Hall as on the advent of Mr. Mitchell.

Patent attorneys and inventors now expect a judicious execution of the patent laws in conformity to long usages and decisions of the Supreme Court of the U.S., both of which have been ignored by the late Commissioner, who has substituted for long usage and established law what he has dignified with the title of decisions of the Commissioner of Patents. Your readers have had submitted to them many extraordinary decisions of the *ex* Dogberry. The New York *World*, a newspaper having the largest circulation of any paper in the world, next to that of the *Petit Journal* of Paris, published the following remarks:—"Mr. Benton J. Hall, Commissioner of Patents, after a year's solemn deliberation, has finally rendered a decision in the interests of the Bell telephone monopoly, as it was predicted he would. Mr. Hall will retire from office in a few weeks. One of his predecessors, Mr. Butterworth, rendered the Bell people a similar favour just before retiring. The peculiarity of Hall's decision is that he refused inventor McDonough, whose patent antedates Bell's, the privilege of demonstrating before him the capabilities of his apparatus in transmitting speech upon a principle never before applied. Compared with Hall, the agent of the Bell monopoly, Mr. Garland stands out as a luminous ornament of the Cleveland Administration."

Bell Telephone Company's Business.—The annual meeting of the American Bell Telephone Company was held in Boston recently, President Howard Stockton in the chair. While the balloting for directors and other officers was in progress the annual report was read. It says:—"Your directors believing that a part of the income from royalties should be treated as capital, have transferred $600,000 from the net surplus for the year to a reserve account. The company earned in the year 24·45 per cent. on the stock, and has assets of $258 per share. The long distance service has been extended from Albany to Buffalo, and new lines have been built from Chicago to Milwaukee and from Boston to Providence. Additional pole line has been built from New Haven to New York. About $2,200,000 has been spent on long lines, which now comprise 26,083 miles of wire. The gross earnings of the year were $3,865,118; expenses, $1,450,913; net earnings, $2,414,205; total dividends, $1,789,878. Deducting the reserve for general depreciation, the surplus account remains the same as last year—$2,028,035. Number of exchanges show an increase of 3; branch offices, 452—no increase; miles of wire, 170,471—increase, 24,033; subscribers, 171,454—increase, 12,742; instruments under rental, 411,511—increase, 31,234. The reports of the 50 licensed telephone companies within the United States show a steady increase of business and a conservative management. There are 947 extra territorial lines, with 73,293 miles of wire, an increase of 20 lines and 18,500 miles of wire. Of underground wires there are 17,384 miles—increase, 9,000 miles. Of this increase New York had 4,083 miles."

That your readers may have an idea as to the extent of the use of the telephone in the United States I send you the official report of the telephone company which operates in the State of Connecticut, which has a population of only 622,000.

The extent to which the telephone has entered into Connecticut's social and business life is graphically shown by the summary of the figures in the Southern New England Telephone Company's annual report which has just been published. There are 2,586 circuits in the State, 6,981 miles of wire, of which 753 are copper, and 5,719 stations, 2,793 of which are business places; 194 persons are given employment.

The stock of the Bell Company has been watered several times, and the *annual net* earnings far exceed the sum actually invested. Last year, profit of nearly 25 per cent. on a capital repeatedly watered was obtained by the exaction of a rent of 14 dollars, equal to £2 2s., for the use of instruments whose first cost is only three dollars and forty-two cents, equal to 13s. 9d. The report of the committee appointed by the Legislature of New York shows "that the net profits of the company exceeded the cash capital in each of the three years, 1885, 1886 and 1887, ranging from 110 to 116 per cent. It is also shown that the company's average annual net profit for each subscriber in the six years ending with 1886 was more than $72. But thus far the combined forces of the local company and the parent company have been able to prevent any reduction of rates by legislation."

The legislatures of several of the States have been instigated by an indignant public to attempt to reduce to reasonable terms the exactions of this great monopoly.

The Illinois Legislature last week took important steps in regard to the telephone monopoly, and in spite of a powerful lobby, the Senate has passed a bill reducing the rental of telephones in Chicago from $125 and $100 to $72 per year, and a similar bill will be reported favourably by the House judiciary committee. The bill provides for the following rates: In cities or villages having a population of 60,000 inhabitants or more, $6 per month; in cities or villages having a population of 35,000 and less than 60,000 inhabitants, $4 per month; in cities, towns or villages having a population of less than 35,000 inhabitants and in all other places, $3 per month.

Animals Executed by Electricity.—Final experiments have been made by the New York State authorities to satisfy themselves as to the best means of executing condemned criminals by electricity. The experiments were under the charge of Dr. Carlos F. MacDonald, of the Auburn State Asylum, assisted by Mr. A. E. Kennelly, Mr. Edison's chief electrician, and Harold P. Brown, the electrical engineer.

What shall be the official word for death by electricity is now the question agitated by judges, legislators, lawyers and electricians. Many words have been suggested, among them is "*Electro-mort*," a mixture of Greek and Latin; "*Electrolithe*," a combination of two pure Greek words; thus when the sentence had been carried out it could be said that the victim had been *electrolithed*, and the executioner could rejoice in the euphonious title,

"*Electrolither.*" The learned district attorney of New York has been delving into ancient terms in search of a word, and thinks he has hit the right word in "*virmort*," a combination of two Latin words meaning *man* and *death*. Upon being asked whether these words did not apply to a man dead, whether he had been drowned or hung, and he opened his eyes wide and said, "Oh! I forgot all about electricity."

Baltimore, *March 30th*.

PROCEEDINGS OF SOCIETIES.

Physical Society, March 23rd, 1889.

Prof. REINOLD, President, in the chair.

The following gentlemen were elected members:—Sir James N. Douglas, Sir Douglas Galton, Messrs. C. W. Biggs, C. Capito, A. C. Cockburn, R. E. Crompton, J. M. Gorham, G. C. Gumpel, W. H. Massey, E. Moynihan, F. J. Mudford, R. W. Paul, and C. E. Spagnoletti.

Prof. J. V. JONES read notes "On the use of Lissajous figures to determine a rate of rotatition, and of a Morse receiver to measure the periodic time of a reed or tuning fork." This paper was printed in full in our last issue.

Dr. HOPKINSON read extracts from the following papers: "On the Clark cell as a Source of Standard Currents," by Prof. R. Threlfall and Mr. A. Pollock. The authors find, contrary to ordinary ideas, that Clark cells can be used to send currents of considerable magnitude without the E.M.F. being appreciably changed, and have constructed cells which give ·001 ampère steadily for half-an-hour. This result has been obtained by increasing the size of the cell so that each electrode is about 5 square inches in area, and the internal resistance is about 6 ohms. For the ordinary small test tube cell, the resistance of which may be about 1,500 ohms, the current ought not to exceed ·00001. On closing the circuit the P.D. (potential difference) drops almost instantaneously to its steady value, and when the circuit is opened rises equally rapidly to very nearly the original E.M.F. The cells completely recover in time. If the current sent be too large the P.D. falls for a time, and afterwards rises and tends towards a fixed value. In this respect Clark's cells are greatly superior to large Daniells sending current through the same resistance. The paper contains several tables and curves as well as valuable results respecting the close agreement between the E.M.Fs. of a great number of different cells.

"On the application of Clark's cell to the construction of a Standard Galvanometer," by Prof. R. THRELFALL. A large cell as above mentioned, together with a known platinoid resistance are used to standardise a reflecting galvanometer, constructed with a single movable coil sliding in guides so as to vary the constant in known proportions. Two controlling magnets are carried on opposite sides of a sleeve sliding on a central tube enclosing the long fibre and a small hollow copper cylinder in oil acts as damper. The tangent law was found by calculation to be practically correct up to 15°, and the scale is curved so as to read tangents on a scale of equal divisions. To give this result the approximate polar equation to the curve is shown to be $r = f(1 + 207\,\theta^2 + \cdot0260\,\theta^4)$. In standardising the instrument a known current is sent through it from the Clark cell, and the controlling magnets adjusted till the spot comes to a fiducial mark on the scale. By varying the position of the coil currents ranging from ·001 to ·4 ampère can be measured.

"On the Measurement of High Specific Resistances," by Prof. THRELFALL. The chief points dealt with are the means for producing thin plates of material of known dimensions, the form and methods of magnetising the needles, and the arrangement of suspension found necessary when great sensibility is required. For producing the plates two plane platinised brass slabs are used and kept at a known distance apart by micrometer screws, whilst the material is melted between them. The screws are then withdrawn and the resistance determined by comparison with a megohm, using different E.M.Fs. in the two cases, so as to obtain about equal deflections. As regards the galvanometer, after many unsatisfactory attempts to use one made according to the Messrs. Gray's pattern, the coils of that instrument were mounted in the ordinary way, and used with an astatic combination of magnetised steel discs. Extreme care was taken to obtain discs exactly similar, and a pair of electro-magnets were made to magnetise them *in situ*, so as to obtain great astaticism. For suspending the magnets, quartz fibres were found greatly superior to silk, the zero of the instrument being very indefinite even with a silk fibre 30 inches long. Considerable difficulty was experienced in attaching the mirror to the needle on account of the distortion produced by ordinary cements, and slow drying white paint was ultimately used and found satisfactory.

"On the Measurement of the Resistance of Imperfectly Purified Sulphur," by Prof. THRELFALL and Mr. A. POLLOCK. The apparatus used is described in the previous paper, the galvanometer of 16,000 ohms being arranged to give 1 division for 2×10^{-12} ampères. A mean of the results obtained gives about 11×10^{15} ohms per cubic centimetre as the specific resistance. In performing the experiments many precautions were required to prevent air current and magnetic disturbances, and paraffin keys were found to give much better insulation than ebonite ones. In conclusion, the authors enumerate the chief points to which attention should be paid in designing and using very sensitive galvanometers. They consider it desirable to use quartz fibres at least 6 feet long, to provide very fine adjustments for the controlling magnets, whose supports should be independent of the suspension arrangement, and believe the whole should be placed in a thick, soft iron cylinder.

Mr. BOYS, speaking of attaching mirrors to wires, said he found a very small speck of shellac varnish to be very satisfactory. As regards quartz fibres, Prof. Thelfall's method of producing them differed materially from his, and the fibres were much thicker. He considered it quite unnecessary to use fibres anything like 6 feet long, and thought 15 inches quite sufficient where the weight to be supported was not large.

Prof. AYRTON regarded the results obtained from Clark's cells to be of extreme scientific and commercial importance, for they showed that a very convenient standard of E.M.F. could also be used as a standard for current.

Prof. THOMPSON, after commenting on the convenience of good E.M.F. standards, expressed a hope that Prof. Thelfall would be able to suggest a convenient method for producing a standard ampère.

NEW PATENTS—1889.

4722. "Improvements in coupling devices for electric conductors." H. H. LAKE. (Communicated by A. C. GRIGGS, United States.) Dated March 18. (*Complete.*)

4748. "Improvements in electrical and automatic appliances and methods for manipulating aeronautic balloon batteries in conjunction with aerostatic indicating, fulminating, and fumigating repeating magazine batteries, and in shells for same, for the purposes of warfare." W. HOWSON. Dated March 19.

4800. "Improvements in electric conductors." H. H. LAKE. (Communicated by A. A. Brooks, United States.) Dated March 19. (*Complete.*)

4821. "Automatic electric induction apparatus." L. DE STEIN, A. PODHORZER, and F. H. BACHMANN. Dated March 19.

4846. "Improvements in electric light fittings." C. K. FALKENSTEIN, E. ROUSSEAU, and C. K. FALKENSTEIN. Dated March 20.

4871. "Improvements in the electrolytic process of obtaining copper, zinc, and tin." H. A. SEEGALL. Dated March 20.

4875. "An improved system for electrical transmission of power for traction purposes by direct current." M. IMMISCH. Dated March 20.

4883. "Improved apparatus for showing whether an electrical switch or contact maker is on or off." F. G. HOWARD. Dated March 20.

4889. "Improvements in the generation of power for electric lighting and its application to dwelling houses and buildings generally." J. CERPAUX. Dated March 20.

4901. "Improvements in means or apparatus for use in conveying electric currents for lighting or other uses." R. E. B. CROMPTON. Dated March 21.

4954. "Improvements in electrical battery cases." H. F. PRICE. Dated March 21.

4960. "Improved means for administering electricity to, and otherwise treating, horses and other animals." G. M. LAWRANCE. Dated March 21. (*Complete.*)

4998. "Improvements in magneto-electric machines." G. BOWRON. Dated March 22.

5010. "Improvements in galvanometers." F. V. ANDERSEN. Dated March 22.

5014. "Improvements in switches and in suspenders for overhead conductors in electric railways." C. J. VAN DEPOELE. Dated March 22. (*Complete.*) [Date applied for under Section 103 of the Patents Act, 1883, 22nd August, 1888, being date of application in the United States.]

5063. "Improvements in instruments for the measurement of electric currents and electromotive force." E. H. HUNGERBUHLER and J. T. TODMAN. Dated March 23.

5066. "Improvements in sockets or holders for incandescent electric lamps." P. A. NEWTON. (Communicated by Alfred Swan, United States.) Dated March 23.

5067. "Improvements in photometric apparatus." J. METHVEN. Dated March 23.

5093. "Improvements in electric batteries." W. J. S. BARBER-STARKEY. Dated March 25.

5095. "Improvements in the form and manufacture of the frames, plates, and cells of storage or secondary batteries." T. J. HASLAM, Jun. Dated March 25. (*Complete.*)

5104. "Improvements in apparatus for communicating, by means of an electric current, with railway trains when in motion." A. E. LEWIS. Dated March 25.

5107. "Improvements in electro-chlorinating auriferous ores." E. M. H. ANDREOLI. Dated March 25.

5111. "Alarms for announcing electrically the discharge of automatic fire sprinklers." D. LEVISON, C. M. DORMAN and R. A. SMITH. Dated March 25.

5116. "Improved electrical storage battery or accumulator." T. PEASE. Dated March 25.

5127. "Electric razor." E. J. DAVIS. Dated March 25.

5131. "Improvements in transformers for alternating currents." A. I. GRAVIER. Dated March 25.

5140. "Improvements in the laying of underground conductors for the conveyance of electricity." S. W. BAYNES. Dated March 26.

5142. "Improvements in systems of electrical distribution." S. C. C. CURRIE. Dated March 26. (*Complete.*)

5152. "Improvements in electrical, gas, or other lamp globe or shade holder." E. ATKINS. Dated March 26.

5160. "Improvements in or relating to terminal shackles for wires carrying electric currents." J. PIGG. Dated March 26.

5176. "Improvements in or connected with electrical installations." E. A. SPERRY. Dated March 26. (*Complete.*)

5209. "Improvements in electrical alternate current motors." M. H. KILGOUR. Dated March 26.

5241. "Improvements in magnets, magneto-generators and telephones." P. M. JUSTICE. (Communicated by E. M. Greene, United States.) Dated March 27. (*Complete.*)

5251. "Improvements in generating and storing electric energy." R. KENNEDY. Dated March 27.

5282. "An electric time indicator, with or without calendar." A. H. GLADWIN Dated March 27.

5291. "Improvements in synchronous alternating current motors." C. ZIPERNOWSKY, M. DERI, and O. T. BLATHY. Dated March 27.

5293. "Improvements relating to apparatus for the distribution and conversion of electric currents." T. H. HICKS. Dated March 27. (*Complete.*)

5348. "Measuring and regulating electrical frequency and currency." W. E. AYRTON and J. PERRY. Dated March 28.

5357. "A novel construction or arrangement of appliances for measuring or ascertaining electric energy, and for recording the voltage or ammeter of currents." J. J. RATHBONE. Dated March 28.

5377. "Improvements in electrical testing instruments." F. KING and W. P. MENDHAM. Dated March 29.

5391. "Improvements in the method of and appliances for insulating electric wires." H. ARON. Dated March 29.

5423. "Improvements in conduits or supports for electric conductors." F. KING. Dated March 29.

5509. "Improvements in electric arc lamps." H. E. FENNER. Dated March 30.

5511. "Improvements in obtaining electricity." W. BOGGETT. Dated March 30.

ABSTRACTS OF PUBLISHED SPECIFICATIONS, 1887.

15484. "Improvements in safety devices for use in connection with electrical circuits, especially those whereon the currents produced by continuous or alternating current transformers are employed." P. CARDEW. Dated November 12. 8d. The inventor combines together:—1st, a body or apparatus (a Geissler tube) which acts as a nearly perfect insulation for currents of low or moderate tension, but which permits of a comparatively free passage to currents when the difference of potential is sufficiently high to be dangerous to human life; 2nd, a small electro-magnet used as a relay; 3rd, a circuit-closing device; and 4th, a circuit-breaking apparatus. The claims are 3 in number.

1888.

249. "Improvements in apparatus for measuring and registering electric currents, applicable also as an electro-motor." J. T. ROE. Dated January 6. 8d. The inventor utilises the heat caused by a current of electricity traversing a conductor or electrical apparatus by using the said heat to expand gases or fluids that are contained in a chamber or cylinder made of suitable material and shape, so that the pressure caused by the expansion of such gases or fluids acting upon a piston fitted with suitable gear causes it to rise and fall, and in such rising and falling by suitable mechanism opening and shutting valves arranged so as to govern or regulate the rising and falling of the said piston which by such action gives motive energy to suitable gear or mechanism for recording and registering the quantity or value of electric currents passing through a conductor or electrical apparatus. The claims are 5 in number.

609. "Improvements in apparatus for determining the poles of electrical circuits and generators of electricity." A. BERGHAUSEN. Dated January 14. 8d. A glass tube is filled with a greasy fluid and closed at both ends by means of caps. Inside the glass tube two platina pins are also fixed on the caps and reach into the greasy fluid. As soon as the current passes the wires the fluid on the negative pole will appear in a rose colour as the pole wire itself receives a coloured cover. The circuit is then immediately broken by removing the wires and the whole apparatus shaked, whereby the rose colour will entirely disappear and the fluid again have its former clear-as-water-colour. The claims are 5 in number.

925. "New or improved electric measuring and recording apparatus." J. G. LORRAIN. Dated January 20. 1s. 8d. The principle of the invention lies in the alteration of shape of an expansible vessel through the alteration of the pressure of a suitable fluid contained therein, such alteration of pressure being brought about by alteration of temperature caused by the passage of the electricity to be measured and recorded, or a portion thereof, through a conductor placed in the said expansible vessel. The motion of the expansible vessel may be communicated to any convenient form of mechanical counter, or it may call into action what is known as an electric counter. The parts of this apparatus may be multiplied, and suitable switching devices may be employed for switching the current from one conductor to another. The claims are 18 in number.

1024. "Improvements in and connected with electric coils." L. S. M. PYKE and H. T. BARNETT. Dated January 23. 8d. The inventors construct the magnetic portion of their coils in such a manner that it has the form of a hollow cylinder of large diameter (that is to say one in which the ratio between diameter and length is much larger than usual) open at both ends, the magnetic poles being at the two ends. The claims are 6 in number.

2666. "Improvements in dynamo machines and electro-motors." J. V. SHEBRIN. Dated February 22. 8d. The inventor constructs the field magnets and the armature in dynamo machines and electro-motors of laminæ of charcoal iron and enamels them after having first coated them with copper, tin, nickel or metal oxide by means of electro-deposition. The parts are united by through bolts and insulated by washers of vulcanite fibre, asbestos, or other suitable material. The armature plates or laminæ are made with outer projections or not. The field magnet plates or laminæ are jointed at the top in the manner and of a form somewhat similar to a pair of calipers so that they can be pulled apart for winding, and then pushed together, their circular parts then embracing the two sides of the armature. The claims are 3 in number.

3590. "Improvements in electrical transformers and plates therefor." J. G. STATTER. Dated March 8. 8d. The complete transformer is similar to that set forth in a former specification except that in its construction buckle shaped plates are employed instead of E-shaped plates or compound plates. The claims are 3 in number.

3710. "Improvements in electro-magnetic motors." J. TWEEDDALE. Dated March 10. 8d. Claim:—In an electro-magnetic motor arranging one or more electro-magnets, the exciting electric currents of which are periodically changed by a commutator to operate in connection with one or more permanent magnets or electro-magnets the exciting currents of which do not change, and by alternate attracting and repelling actions to produce reciprocating movements and by means of one or more connecting rods and cranks impart rotation to a shaft, the parts being constructed to give turning or angular movements to the magnets, and the pole pieces of the magnets being of curved forms such that the turning movements bring successive parts of the pole pieces into proximity, substantially as described.

3841. "Improvements in telephonic apparatus." T. LAURIE. Dated March 13. 8d. According to the present improvements in transmitters, the electrodes are all situated loosely, that is to say in a free state within the transmitter. The lower electrode consists of two pieces of carbon which constitute a disc with a recess in its centre. The two pieces constitute a disc and have a layer of fibre or other insulator between them. The improvements, which relate to the receivers in telephonic receivers, partly consist in causing one face of the membrane diaphragm to bear against a ring having a V-shaped or an equivalent edge equidistant from its centre and against which the diaphragm is pressed with a practically constant degree of tension by the action of springs, thus any variation due to differences of moisture acting upon the diaphragm are taken up by the elastic pressure of the springs stretching the membrane diaphragm over the V-shaped or equivalent edge of the aforesaid ring. Also relates to signalling apparatus. The claims are 6 in number.

3981. "Improvements in and connected with means for driving, controlling, and working electrically-propelled vehicles, cranes, and the like." E. HOPKINSON. Dated March 14. 8d. The inventor carries the magnets and pole pieces of the motor dynamo between which the armature revolves wholly or in part directly from the axle (and not from the framework of the car, as is usual), supporting their weight on sleeves or bearings in which the axle revolves. The claims are 7 in number.

4345. "Improvements in the method of and apparatus for distributing electrical energy by alternating currents from central stations." G. KAPP. Dated March 21. 8d. The inventor dispenses with rheostats or artificial resistances altogether, and keeps at the dynamo terminals exactly the same pressure as that which must be maintained between the primary terminals of the transformers. This pressure is a constant. He obtains the increase of pressure necessary in each feeder for overcoming its electrical resistance by inserting into it at the station the secondary

coil of a regulating transformer, the primary coil of which is coupled as a shunt across the terminals of the dynamo. When several dynamos are used he couples them in parallel by means of two main bars, and the connections of the primary coils of the regulating transformers are then made with these main bars. He provides one of these regulating transformers to each pair of feeders. The primary or fine wire terminals of these regulating transformers are permanently connected with the main bars, and the secondary coils are divided into sections and connected with a suitable switch, so that by adjusting the switch a greater or lesser number of turns of the secondary coil can be inserted in series into one feeder of each pair. The coupling up of the regulating transformers is such that the electromotive force produced in their secondary coils is added to the electromotive force of the current in the feeders. He sets the switch of each regulating transformer so that the electromotive produced in the secondary coil is just sufficient to overcome the resistance of the feeder at the current then flowing. The pressure available at the distant end of each pair of feeders is then exactly equal to that constantly maintained between the main bars at the station.

4489. "An improvement in holders for electrical glow lamps." E. F. H. H. LAUCKERT and E. H. HAENSEL. Dated March 23. 8d. Claim:—In combination with the holder of an electric glow lamp, and the tube or plate to which it is screwed a spring fixed to the tube or plate, and having a slot or groove engaging with rounded studs on the lamp holder, substantially as and for the purpose set forth.

4593. "Improvements in electrical batteries and methods of closing the same." F. L. RAWSON and W. WHITE. Dated March 26. 8d. In the outer casing of the cell the inventors let in a stopper preferably made of a hard material, which is not attacked by the acid of the battery. This stopper is made so as to act as a stuffing box, having a receptacle at the top to contain material such as glass or slag wool, cocoa nut fibre, or some such substance which is not attacked by the acid. A plug is arranged so as to screw down upon the glass, wool, or other material, so as to compress it to any degree of hardness. The gas evolved passes easily through the material, passing first through a small hole or holes bored in the stopper, whilst the liquid can only pass slowly through the material. The claims are 2 in number.

4604. "Improvements in automatic apparatus for the continuous opening and closing of electric circuits." L. S. M. PYKE and H. T. BARNETT. Dated March 26. 8d. The principal feature of the invention consists in producing the interruptions by means of a separate apparatus, the magnet, armature spring and contact points being all included in a shunt circuit, and the interruption of the main circuit being effected mechanically by the movements of the armature of the electro-magnet which is included in the shunt circuit. The claims are 2 in number.

4940. "Improvements in and relating to alternating current dynamo-electric machines." T. PARKER. Dated April 3. 8d. Claims:—1. An alternating current machine having rotating field magnets, a fixed armature surrounding the field magnets, flat or flattened armature coils and a laminated iron armature core, all constructed and arranged substantially as described. 2. In an alternating current machine; an armature composed of a laminated iron ring having a series of flat coils arranged edge to edge on its inner circumference, substantially as described.

5233. "Improvements in fusible cut-outs for electrical circuits." A. H. WALTON. Dated April 9. 8d. Claims:—1. In electrical circuits a contact bar for any number of fuses, this contact bar to form a point of distribution. 2. In a contact bar, the means substantially as described and illustrated in the drawings for providing improved methods for inserting fusible cut-outs in electrical circuits.

CORRESPONDENCE.

Re Series Line at Northfleet.

Enclosed I beg to hand you copy of a letter in reply to that of Mr. Spence's in the *Engineer* on this subject, upon which you have commented. I trust you will insert same in this week's ELECTRICAL REVIEW, which favour I shall greatly esteem.

E. Manville.

April 10th, 1889.

The Series Electrical Traction Syndicate, Limited,
11, Queen Victoria Street, E.C.
April 10th, 1889.

Sir,—*Northfleet Series Tramway.*—My attention has been called to a letter in your issue of the 29th March from Mr. Spence, commenting upon some of the statements published by you with reference to the above.

Now, Sir, I cannot allow that a much higher potential than 200 volts can be used with safety in parallel runnings for the whole length of a line five miles long, as the one taken as an example within a few inches of each other are bare conductors, with the full difference of potential between them. We have all of us heard of the difficulties that have been experienced in a certain well known line, where the differences of potential, I believe, is not above 200 volts. On the other hand, it is not our intention to use a current with a maximum difference of potential of 6,000 volts, as suggested by Mr. Spence. This figure was merely taken so as to get the current quantity the same in the comparison between series running and parallel running at 200 volts. We do, however, intend to use currents with a maximum difference of potential of 2,000 volts, as 1,800 volts difference of potential has already been used in practice on this system, under very bad electrical conditions, with excellent results.

However, allowing Mr. Spence the use of 400 volts, the condition of affairs is really not much altered. To start with, he halves the length of the line by placing his station at the midway point. This, of course, would involve, in a large tramway system, a separate generating station for each section of their line, and on some of our largest systems this might mean no less than 10 or 12 stations.

It is our contention that the series system is particularly adapted for large systems, and the comparisons between it and parallel running are made on that basis; but whilst Mr. Spence puts his parallel generating station at a point midway on the line, he still leaves us at the end of the line, and then attempts to effect comparison. Surely his calculation should be made on the basis of both stations being in the centre? Again, after dividing the line into two separate circuits, he takes the average distance on either side of the generating station as being 1¼ miles, that being half of the 2¼ miles.

Now, Sir, does Mr. Spence imagine that Nature is going to give him a return of absolutely no resistance? In practice I am afraid this is not so, and that therefore we must reckon the length of the electrical circuit on each side of the generating station as being 1·25 miles × 2 = 2·5 miles. This would alter Mr. Spence's calculation on the 400 volt basis very materially.

375 ampères × ·3 ohms = 111 volts; and then 111 volts × 373 ampères = 56 H.P. loss in the conductor on each side of the generating station, or 112 H.P. in all. 112 H.P. is no less than 28 per cent. of the total energy delivered to the conductors. As against this, a station in the same position on the line, running each of the two sections in series, and limited to 2,000 volts as the maximum difference of potential, the comparison would be ·6 ohms with 75 ampères = 4·5 H.P. on each section, or a little over 2 per cent. of the total energy delivered to the conductor. Perhaps, however, Mr. Spence does not consider 28 per cent. too much to lose in the conductor, and therefore we will compare the difference in the cost of the conductor when losing the 28 per cent. running in series as is shown to be lost while running in parallel. The resistance of our circuit, then, may be 7·3 ohms for 2½ miles double circuit, or about 1·4 ohms per mile. This represents a conductor weighing only 727 lbs. per mile, and costing, when insulated in the best possible manner, only £177 per mile. As against this, the conductor when losing at 400 volts 28 per cent. on the parallel method, would weigh about three tons per mile and cost about £1,350. The difference in these two costs is almost enough to build our conduit. So it would appear that even placing the generating station in the position that Mr. Spence requires, limiting our difference of potential to 2,000 volts, and raising the difference of potential on the parallel method to 400 volts, that the difference in efficiency in either cost or power is much in favour of the series method.

It is interesting to note what size of conductor would be required at 400 volts in the parallel method to lose 25 per cent. only if the station had to be placed at the end of the 5-mile line, as would occur in practice on large systems; and I, Sir, give the figures with bated breath! The total resistance of the conductor could then only be ·178 ohms, or ·0356 ohms per mile. Such a conductor would weigh no less than 25,000 lbs. a mile, and cost, when properly insulated, not less than £5,000 per mile.

There are other remarks in Mr. Spence's letter which pass my comprehension; I mean the reference to compensation to widows and children of late car drivers and linemen. I cannot suppose that he would suggest linemen would have the opportunity of working upon circuits while tramcars were running, and one might expect that he would give one credit for sufficiently good design to render the danger to car drivers absolutely *nil*. Has Mr. Spence thought of the difference in maintenance of electrical machinery between series and parallel running? Does he not know the infallible result of putting the low resistance armature of a motor suddenly across conductors with a difference of potential of 400 volts between them, as it is in the power of any careless car driver to do? If he does not know this, it might be instructive for him to obtain information as to the number of armatures burned up on the Richmond (Virginia) Road, where a difference of 500 volts potential on overhead conductors is used. In the constant current method it is impossible to burn up the armatures of the motors, and I can only say that I would sooner pay the compensation to widows and children of late car drivers and linemen operating on the series tramway system at 2,000 volts difference of potential, than pay for the repairs to armatures of motors on a parallel system at 400 volts difference of potential.

Yours faithfully,

E. MANVILLE,
Electrical Engineer, Series Electrical Traction Syndicate.

The Editor, the *Engineer*, 162A, Strand.